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THE

ENGINEER'S MANUAL

OF

MINERALOGY AND GEOLOGY.

Price 3s.

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1622.

THE

ENGINEER'S MANUAL

OF

MINERALOGY AND GEOLOGY;

OR,

GUIDE TO THOSE WHO ARE IN SEARCH OF THE VALUABLE
METALS ESSENTIAL IN

Practical Science:

INDICATING THE VARIOUS

ROCKS AND STRATA OF ENGLAND AND WALES;

AND

THE PRINCIPAL ORES AND OTHER MINERAL SUBSTANCES
WHICH ARE TO BE MET WITH IN THEM,
AND THE MEANS OF RECOGNISING THEM.

BY MRS. VARLEY,

AUTHOR OF "CONVERSATIONS ON MINERALOGY," AND OTHER ESSAYS
ON THE SAME SUBJECT.

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THE

ENGINEER'S MANUAL

OF

MINERALOGY.

AMONG the various kinds of knowledge which contribute to the comforts of mankind in a civilised state, none is more valuable than that which makes us acquainted with the mineral matter of which our earth is composed. This may be considered, in a general point of view, as consisting principally of *earthy* and of *metallic* substances; the former being considerably more abundant than the latter, which are contained chiefly in the fissures of rocks, called *veins* or *lodes*, seldom forming beds or strata, and never existing in the form of mountains. From a very early period, the mutual utility of both kinds of substance has been known; for if stone were found to be a valuable building material, metals soon became indispensable in forming tools to fashion it. For an endless variety of purposes, the ores of metals have been continually sought for, and brought to light; sometimes from indications of their existence appearing on the surface of the earth, or in the beds of rivers, (as in the case of native gold and silver, which have frequently been observed by persons who never thought of looking for them,) sometimes vaguely, by quarrying where a natural fissure or other exposure of the rock afforded a convenient spot for investigation.

Frequent disappointments, as well as success, led to observations on the kinds of rock or stratum which contained the various ores: thus, in a country where the rocks are granitic, we may look for the ores of tin, copper, or iron; being guided by other specific or local circumstances and peculiarities, as to the degree of probability of finding one or the other, or all of these, in the same neighbourhood. On the other hand, if we traverse a chalk country, experience will point out the inutility of sinking a mine with the expectation of finding any metallic ores, since none exist in this formation, except iron pyrites, which is not available for the production of metal.

For want of this knowledge many disappointments have been incurred, and much money has been wasted by enterprising individuals, who have sunk mines to find metals and coals, which did not exist within a hundred miles of the locality so explored. Others, from ignorance of mineralogy, have been so far deceived by some of the external appearances of the substances they met with, that they have erected furnaces, and all other necessary apparatus, for the smelting of minerals which contained no metal whatever. An instance of the latter sort occurred between forty and fifty years ago, near Colebrookdale in Shropshire, when a man finding some mica in small scales or plates, having a very silvery lustre, was persuaded that he had discovered a silver mine, and ruined himself in trying to obtain the metal from it. In the same county, the sulphate of barytes was mistaken for white lead ore, and ineffectually exposed to the process necessary for obtaining lead.

The object of the present work is to enable engineers and others, whose occupation gives them frequent opportunities of examining rocks and strata, to profit by the facilities thus afforded them;—to assist them, by a description of the external characters of minerals, to recognise them when they occur, and also to furnish them with some data on which to found their expectations of meeting with such or such minerals, according to the nature of the strata through which it may be their business to cut or excavate.

On looking at a geological map of Great Britain, we see that the older formations, slate and granite, occupy the south-western counties, Cornwall and Devon. These rocks are rich in veins affording metallic ores, especially tin and copper, which have been obtained from the Cornish mines ever since the period when the Phœnicians were the most commercial of nations: from the mines of Cornwall they obtained the tin and copper of which they manufactured their armour.

A large portion of Wales, including the most mountainous parts, presents also rocks of slate, but is destitute of granite* and the ores of tin. In Cumberland we find slate which geological researches have ascertained to be of still more remote origin, interspersed with patches of granite; and here we have mines of lead ore, sparingly interspersed with other metals. As we proceed towards the eastern coast, the rocks which are visible at the surface of the earth present successively the characters of a more and more recent origin, affording less and less metallic ores, and a continually increasing proportion of fossilised organic remains, till at length the former disappear, with the exception of that universally distributed mineral, iron pyrites. If, therefore, an engineer were required (supposing it possible) to carry a cutting from the Land's End in a right line to the coast of Essex, and to look for the metalliferous minerals of each formation or rock, he would, in Cornwall and Devon, as far as to the east side of Dartmoor, cut through—

---

* Except a small spot in the Isle of Anglesea.

1st. Slate (termed there *killas*) and granite; intersecting a vast number of veins containing the ores of tin, copper, lead, iron, and other metals in smaller quantities.

2dly. Limestone, associated with coarse sandstone, which terminates near Exeter.

3dly. The new red sandstone, (accompanied in other localities by beds of rock salt and gypsum,) containing, but sparingly, veins of copper and zinc ores.

4thly. Beds of limestone, termed *lias*, separated by thick beds of clay and other minerals.

5thly. Oölitic strata, of which the Portland stone and Bath freestone are varieties.

6thly. Chalk (with greensand).

7thly. Plastic clay, some of the lower beds affording pipe-clay.

8thly. London clay, a thick bed of considerable extent, on which lie the sand and gravel of Hampstead, and other places near London.

A similar example may be given, by supposing it required to cut from Whitehaven to the mouth of the Tyne. In this part of the country we meet with a large tract of the carboniferous* or mountain limestone, and coal-beds; and with these are associated slaty sandstones, the coarse granular sandstone called millstone grit, and clay iron ore. In the carboniferous limestone we may also expect to find lead ore, since in Durham, Cumberland, and Yorkshire are numerous lead mines situated in this calcareous stratum; while the iron ore is raised near the collieries. Going in a direction E. N. E. from Whitehaven (which stands on the extremity of a small coal-field*), after passing through the mountain limestone, we come to slate rocks of great antiquity, and to the north of Keswick, an isolated ridge of granite; the mountain lime appears again to the east of the slate, and after crossing a tract occupied by the new red sandstone formation, we meet with it again, surrounding another coal-field; it is succeeded by the sandstones and coal-measures, which extend to the eastern coast.

---

* So called from the coal-beds, which are generally associated with it.

It may perhaps occur to the reader, that as so much pains have been taken to construct geological maps with the greatest possible accuracy, and as every part of our island has been so frequently explored by eminent geologists, he need only consult such an authority before he begins his operations, and that he will be able to know, with tolerable certainty, what rock or mineral he will meet with at any given point. But, to trace the line of junction of any two rocks or strata is much less easy in nature than to understand their relative position when represented on paper: the partial mixture of the two substances, the difficulties arising from the inequalities of the surface, and other disadvantageous local circumstances, render it difficult to follow the line of junction uninterruptedly, and make it always presumable that some new feature may frequently be met with; and that portions of strata hitherto unobserved may be discovered to exist, either at the surface of the earth, or at some depth below it in the neighbourhood of an adjacent formation; and even in some cases in an isolated situation.

---

* Coal-field is the geological term for a tract of country occupied by beds of coal, which are called in the North of England *coal-measures.*

It is clear, therefore, that we ought in such operations to compare and combine an accurate observation of whatever comes under our own cognizance, with facts already established; and every new incident, however trifling it may at first appear, if recorded with precision, will become valuable as an addition to the geological knowledge we already possess.

We must now give some definition of the terms *Stratum*, *Vein*, *Cross-course*, *Stratified*, *Unstratified*, &c.; and afterwards, of the substances (both rocks and simple minerals) which occur in these forms, circumstances, and situations.

In traversing either of the lines we have mentioned, the traveller will find, that the rock or earth of which any tract is composed lies upon some other, either horizontally, or somewhat inclined to the horizon, often preserving, unless where it rises into mountains, a tolerably equal thickness and parallelism throughout its extent. Thus, the different kinds of oölite, and the different beds of lias limestone, rest upon each other, forming parallel layers, separated by alternate layers of clay and shale: these beds, or layers, are called *strata*, and the whole formation is said to be *stratified* (*fig.* 1.). Evidences of this arrangement are constantly to be met with in nature, and may often be observed, without giving ourselves the trouble to dig or penetrate into the earth; for example, in many hills we find natural sections exhibiting the succession of strata, which occur always in the same order of superposition. Cliffs along the sea-shore, on the coast of Yorkshire, Kent, Hampshire, and other parts of England, exhibit instances of the stratification of limestone, sandstone, chalk, clays, and sands. It must be remembered, and will be seen in the examples just mentioned, that the strata are rarely, if ever, perfectly horizontal; were this the case universally, the surface of the earth would always exhibit the same substance, and we should never obtain certain other minerals without excavating to a great depth. But the natural inclination of the strata affords us in innumerable instances, opportunities of examining many, within a small depth and very limited space. (*figs.* 1. & 2.) This inclination, which generally preserves the same angle throughout any one stratum, is called the *dip ;* and we say that a stratum *dips* to the east, to the north-east, &c. We have said, that *generally* a stratum preserves nearly the same thickness throughout its extent; but it sometimes happens that the thickness diminishes considerably in some part or other, and occasionally the bed disappears entirely from between the strata lying above and below it (*fig.* 3.), or the intermediate stratum, as it is technically called in geology, thins out. Sometimes a stratum is wanting, to complete the usual order of succession; but this deficiency will be found on examination to be local; and if we trace the superior and inferior beds to a distance, we shall find, in some part or other of their extent, all the strata belonging to the formation, of which it forms a part, in their proper order of superposition; for it must be remembered that this order, though it may sometimes be imperfect, is never reversed.

There are other rocks, which offer no appearance of stratification: they are generally composed of two or more simple minerals, all closely intermixed, and constituting as it were a solid paste; and this compound mineral forms mountains or rocks, or irregular masses, but not strata. Such are granite, syenite, porphyry, greenstone, basalt, and their varieties, the latter being one of several rocks included under the generic name of *trap.* These two classes of rocks are characterised by a striking difference in their internal structure: the unstratified ones are frequently crystalline throughout, as granite and syenite; others are granular, as quartz rock; and some compact, as basalt; but they all possess the characters of minerals produced by the fusion or baking of volcanic heat, while those which are stratified bear evidence from their texture, as well as from their situation, of being depositions from water.

Both stratified and unstratified rocks are intersected by *veins* (called, in Cornwall and Devon, *lodes*) of various descriptions: in some cases they are composed of earthy minerals; in others they contain the metallic ores, the greater part of which occur more abundantly in these repositories than in any other situation. These veins are themselves thin beds; but, instead of forming a part of the *stratification* of any rock, they traverse it in a nearly vertical direction (*fig.* 4.); their dimensions vary exceedingly, from a line in thickness to the width of several feet: in some, the sides or walls preserve nearly the same distance from each other; in other cases they widen into large irregular cavities. The quantity of ore they contain is equally uncertain; many veins are full of ore in some parts, and in others contain but little, and sometimes none, being filled with earthy minerals. We generally find that some particular rock or mineral accompanies almost constantly the ores of any one district; this is called by miners the *vein-stuff*, and by mineralogists the *matrix* of the ore. In Cornwall, and the slate district of Wales and Cumberland, quartz is the most usual matrix; in Derbyshire, and part of Yorkshire, fluor spar and sulphate of barytes are the most common vein-stones of the lead mines.

The extent of veins is not limited to one kind of rock; they frequently traverse two or more adjoining ones, as in Cornwall, where the tin and copper veins penetrate both the granite and killas; appearing, therefore, to be of less ancient origin than either. These again are intersected by other veins called *cross-courses*, which must be apparently of still more recent formation. They are filled generally with earthy minerals, but in some instances contain ores, though these cases are not frequent, except at the intersection of the cross-course with a metalliferous vein or lode. (*fig.* 5.)

It is not intended to give the reader a *treatise* either on geology or mineralogy; but it is necessary to give him a general outline of the geological relations of the different rocks in which ores of metals may be found, and some of their distinguishing mineralogical characters, beginning with

THE UNSTRATIFIED ROCKS.

Granite.—A crystalline rock, more or less granular, of which the basis, or principal ingredient, is felspar; usually white, grey or of a reddish colour, exhibiting distinctly the planes of crystallisation (or cleavage), which give it a bright glassy appearance. The other components are quartz and mica: the quartz is most frequently white or greyish, transparent, more or less regularly crystallised, or in grains; the mica exists in the form of minute shining scales or plates, either black or grey, having a semi-metallic lustre. It must be remembered that both quartz and felspar are considerably harder than steel; that felspar, if crystalline (as in granite), breaks with a flat polished surface, and straight edges; and that quartz, when broken, exhibits the form and lustre of fractured glass. The size of the grains of these three substances varies considerably; and occasionally, but rarely, the mica is nearly or totally wanting. Scotch granite is so well known as a paving-stone in London, that it is not necessary to go farther to cite specimens of it: it is generally very compact. The granite of which Waterloo Bridge is constructed (with the exception of the balustrade) is from Dartmoor; it is of much looser texture, and is less shining in its fracture, than that of Scotland.

Besides the metallic ores, which the veins traversing the granite afford so abundantly, they contain, in certain localities, small crystals of topaz, garnet, tourmaline, epidote, hornblende, augite, schorl, and some uncrystallised minerals; as serpentine, soapstone, and hypersthene.

Syenite consists essentially of felspar and hornblende, a mineral of a dark blackish-green colour, or quite black; it is sometimes crystallised, sometimes intimately mixed with the felspar, and exhibiting an uneven fracture with considerable lustre: grains of quartz are frequently intermixed with the felspar and hornblende, and sometimes scales of mica. Syenite varies much in colour, from the variable proportion of the ingredients and the colour of the felspar, which may be white, grey, or red. The Malvern Hills are of syenite.

GREENSTONE.—A granular, and generally dark-coloured rock (not, however, always characterised by a green colour), consisting of the same materials as syenite, or of felspar and augite, a granular crystallised mineral of a dark olive-green colour, considerably resembling hornblende: but the grains are generally more minute and more intimately mixed than in the former rock.

BASALT.—Composed of the same ingredients as the two preceding rocks, but still more intimately mixed, so as to produce a compact fine-grained substance, presenting no crystalline structure, but containing crystals of various substances imbedded in it, or contained in small cavities, as the white crystals of zeolite in the basalt of the Giant's Causeway, in the north of Ireland. Its general colour is black or blackish grey.

PORPHYRY (called in Cornwall, ELVAN).—It must not be imagined that this term is confined to the designation of the dark red or dark green stone, generally known as *antique* porphyry; it signifies, in geology, any rock of which the base is compact, and contains numerous crystals, *chiefly of the same kind*, imbedded in it. The crystals which impart the porphyritic character to a rock are of felspar, generally either greyish, reddish, or pure white; sometimes opaque, sometimes transparent; and the small spots which characterise the antique porphyries are of the same substance. Many examples of porphyry occur in Cornwall and Scotland, also in Northumberland.

All these rocks, with the exception of granite, belong to a class called the *trap formation*, which contains likewise some others, so variable in their aspect and composition, that it is extremely difficult to give such descriptions as will enable any one not already conversant with the external characters of minerals, and also of aggregate rocks, to recognise them. In Derbyshire there is an extensive formation of trap, called locally *toadstone*, from its spotted appearance; the spots are small cavities, more or less filled by various substances, crystallised and uncrystallised.

The rocks belonging to this series have a peculiarity in their mode of occurrence, which is worthy

Plate I. To face p. 17.

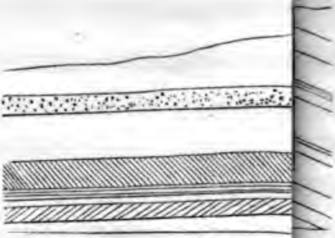

Fig. 1.

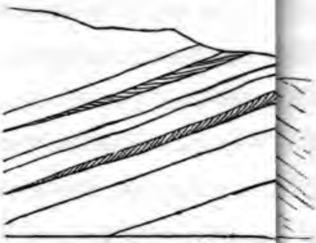

Fig. 3.

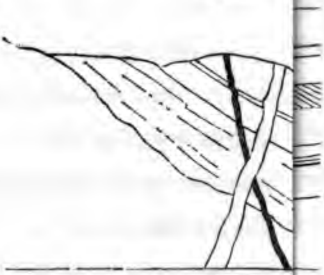

Fig. 5.

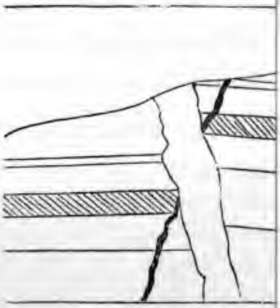

Fig. 7.

of notice: they do not usually form hills; and if they appear to fill veins, these will generally be found to proceed from a large mass of the same rock, which penetrates the stratified ones in various directions. They very frequently form long straight masses, from a few inches to several yards in thickness, called *dykes* in the North of England; the word dyke there signifying a wall, which they much resemble. They seem to proceed, like the cross-courses, without interruption through various strata, veins, &c., and to have produced very remarkable effects on those in contact with them: not only is the character of the adjacent rock altered, but it is frequently displaced on one side or the other.* (*fig.* 6.) Veins of ore likewise are displaced or *shifted* by dykes, to the great inconvenience, and often expense and loss to the miner, who sometimes seeks in vain on the other side, the vein by which he had been profiting. (*fig.* 7.) In some cases, the contiguous rock is hardened in contact with the dyke, in others rendered crystalline (as in limestone), and occasionally compact. Serpentine also belongs to this class of rocks, and occurs in isolated masses, or forms dykes. As examples, we may cite the verde antique, and the variegated serpentine of Anglesea, improperly called Mona marble; we say improperly, because marbles are essentially *calcareous,* and serpentine, though it may be veined or spotted with calc-spar, is essentially *magnesian.* Serpentine is occasionally, but not often, traversed by metallic veins, as that of the Lizard Point, Cornwall.

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* This shifting or dislocation of strata is technically called a *fault* (*fig.* 8.); and it must be remarked, that faults occur very frequently without the intervention of any other mineral. Thus the coal strata are sometimes found to be displaced by a fault, which is apparent at the surface of the earth, dividing and shifting all through which it passes.

STRATIFIED ROCKS.

GNEISS.—This rock consists, like granite, of felspar, quartz, and mica; but, unlike granite, it is laminated or stratified. It is the oldest of the stratified rocks: a fact sufficiently proved by its always occupying a lower position than any other.

MICA-SLATE, or MICA-SCHIST, is somewhat similar to gneiss, but usually contains more mica, and little or no felspar. Quartz-rock, of a white, semi-transparent, and somewhat fatty appearance, occurs abundantly, associated with these two rocks, which occupy very considerable tracts in Scotland. They all contain occasionally crystals of garnet imbedded in them, and local beds (such as are of comparatively small extent) of primary limestone, hornblende-schist, chlorite-schist, and talc-schist. The three latter resemble considerably mica schist, but the mica is replaced by one or other of the substances which give their denomination to these rocks.

CLAY-SLATE.—It is scarcely necessary to describe a mineral so familiar to us as that with which houses are in many places roofed; but, like other substances, clay-slate varies somewhat in its characters in different localities, some slate being much harder than other kinds, and some more variously coloured.* The clay-slate of some districts is of so coarse a texture, that its usual slaty character† disappears *on a small scale,* and it seems to pass into a kind of sandstone.

It alternates frequently with beds of limestone, greywacke slate‡, chlorite, and mica slate, and also quartz-rock; so that when, having cut through a bed of slate, we arrive at a bed of limestone, we must by no means conclude that we have passed from the slate formation to a limestone formation.

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* The killas or slate of Cornwall exhibits many shades of green, greenish and bluish grey, greyish white, lilac, purple, and even crimson and brown.

† The laminated structure of slate must not be confounded with its stratification; for it generally happens that the direction in which slate splits (called the cleavage) is not parallel to its stratification.

‡ Greywacke or grauwacké is a local German name, adopted

The clay-slate occupies a tract in the west of Cumberland, surrounding the granite of Skiddaw; and a much larger one in the south of Scotland, extending quite across the country from Port Patrick to St. Abb's Head, forming the mountains of Lammermuir and Galloway. In both these districts it is traversed by numerous veins of quartz, affording both lead and copper ores; the former occur chiefly in the veins which run north and south, the latter in those which range east and west: cobalt also has been discovered in the copper mines of Newlands, in Durham.

The gneiss, mica-slate, and clay-slate formations are called *primary*, as possessing characters of greater

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by geologists to designate a class of rocks possessing a variable structure, intermediate between granular and slaty. "In its most common form," says Mr. Bakewell, "it may be described as a coarse slate, containing particles or fragments of other rocks or minerals, varying in size from two or more inches to the smallest grain;" so that it sometimes resembles a sandstone, sometimes a breccia with a paste of slate. When the structure is very slaty, it is termed greywacke-slate.

antiquity than any others; and upon them rest several other series, in a regular order of superposition.

The western part of Wales is occupied likewise by a clay-slate formation, which has been distinguished as the *Cambrian group:* it consists of alternate beds of clay-slate, slaty limestone, sandstone, and shale*; and upon these rests another series of stratified rocks, termed Silurian, consisting of alternations of slate, greywacke slate, sandstone, and limestone. Most of these are rich in organic remains, which bear a great resemblance to those of the preceding series.

The slate or killas of Devon and Cornwall, as before mentioned, is rich in metalliferous veins; but its precise degree of antiquity, as compared with that of Wales, is not satisfactorily decided; it is thought, however, to approach in age the Old Red Sandstone formation, (which rests immediately on the Silurian system,) and perhaps to be a portion of it.

The OLD RED SANDSTONE FORMATION occupies the south-eastern part of Wales, Hereford, and Monmouthshire, and several large tracts in Scotland; the principal one extends from Ayr and Greenock on the S. W. to Montrose on the N. E. coast, and is separated by a very narrow band of clay-slate from the mica-slate, which lies to the north, exactly parallel to it. A reference to the geological map will show us that small patches occur in many other places. Its most usual features are, a reddish colour, especially in the lower beds, contiguous to the slate groups, and a granular or sandy structure, forming thick and extensive beds, which contain an abundance of rolled and angular fragments of other rocks; so that it appears to be a conglomerate derived from the older formations. It scarcely contains any metallic veins, but is traversed by veins of calc-spar, sulphate of barytes, sulphate of strontian, and asbestus. To this succeeds the

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* Shale—indurated clay, having a slaty structure.

CARBONIFEROUS SYSTEM, so called from its containing the great coal-fields of England and Wales. It consists of three distinct formations or groups, of which the lowest is the great

1. Mountain, or Carboniferous Limestone.
2. Millstone Grit.
3. Coal-beds (Coal-measures).

This system occupies, in England, the north of Derbyshire, the west of Yorkshire, the adjoining part of Lancashire, part of Cumberland and Westmoreland, nearly the whole of Durham and Northumberland, and the great coal-fields of South Wales. It also occupies in the southern part of Scotland a broad band, running in a S. W. and N. E. direction, and forms a large part of the central counties of Ireland. The same formation occupies the valley of the Meuse, whence the greater part of the coal burnt in Paris is obtained. In South Wales the millstone grit is very inconsiderable, and sometimes nearly wanting, while in Derbyshire and Yorkshire it crowns some of the loftiest hills, and has frequently a thickness of 300 feet.

The mountain or carboniferous limestone comprises the great bed of limestone called in Yorkshire *scar limestone*, and a superposition of several thin beds of shale, various kinds of sandstone (or flagstone), and thin beds of limestone. The lowest, or scar limestone, presents a stratum of from 400 to 800 feet in thickness; as we trace it northward from Derby, the thickness increases, and we find that it is gradually interstratified by thin beds of shale, grit, and even coal (*fig.* 9.), which become more and more numerous as we proceed; and the limestone, being separated into thin beds, assumes a different character, becoming slaty, and much broken up, and appears to mix with and acquire the nature and structure of the shale.

As not only this but other kinds of limestone vary considerably in their appearance, we will give some simple characters which are common to all of them: they may be scratched with ease by a knife, and effervesce briskly on the application of a drop of dilute nitric or muriatic acid. All marbles are varieties of limestone, and chalk, though differing in its texture, is in its composition the same substance—carbonate of lime.

MILLSTONE GRIT is a sandstone of somewhat coarse structure, containing an intermixture of felspar, which is frequently in a decomposed state, resembling porcelain clay, and a small proportion of mica, in pale silvery scales. It varies considerably in different localities; for in some parts of the northern tract, the grains or pebbles of which it consists approach occasionally to the size of an egg, while in the southern coal-fields it is a hard compact sandstone.

The COAL FORMATION (or coal-measures,) consists of alternate beds of sandstone, coal, and shale, with layers of nodular ironstone and bivalve shells, as well as balls of calcareous clay, enclosing other petrifactions.

This group contains no limestone beds, which distinguishes it from those portions of the mountain limestone strata, in which seams of coal occur. The thickness of the coal-beds, compared with that of the intervening sandstones, is very small; in the Newcastle coal district, 47 ft. 3 in. of coal are interstratified with 1141 feet of sandstones and clay: the latter vary considerably in their thickness and quality, while the beds of coal and ironstone are the most regular parts of the formation. In the northern coal-fields the ironstone is confined to the lower beds, and is not abundant. In Shropshire, Derbyshire, and Staffordshire, the ore is clay ironstone. In Lancashire the red oxide of iron occurs in the form of hæmatite and compact red ironstone. In the coal-field of South Wales, the coal-measures, which resemble those of the northern districts in their geological position, contain sixteen beds of ironstone, in layers and nodules. Red oxide of iron, much intermixed with manganese, is found abundantly in Dean Forest, Gloucestershire, in the mountain limestone beneath the coal-measures; while the nodular ironstone of the shale beds is of little importance.

New Red Sandstone System.—This consists of two series or formations. The first, or lowest, includes a bed of magnesian limestone, accompanied by an inferior bed of red sandstone, which lies unconformably* on the coal-measures; and above these, gypseous marls, red or bluish, and limestone stratified with other beds of coloured marl. The second group, resting on the last-mentioned strata, comprises variegated and red sandstone, some portions of them being white and mottled; and above them numerous beds of argillaceous marl, generally affording gypsum (or alabaster), as in Nottinghamshire, where it is extensively quarried, both for ornamental purposes, and to burn for plaster of Paris, and in Somersetshire, near the Bristol Channel—and also partially beds of rock-salt, as in Cheshire. The gypsum, which is a sulphate of lime, is a much softer substance than the carbonate of lime, or limestone; the fibrous variety, and even that which has the structure of fine-grained marble, may be broken by the nail. The magnesian limestone, which is peculiar to this formation, may be distinguished from the mountain (or pure) limestone, by its effervescing much less briskly on the application of acids, and also by a difference in their general appearance. It is generally of a yellow tint, less compact than the carboniferous limestone, but with a somewhat vitreous lustre when freshly broken.

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* The meaning of this term, frequently used by geologists, will be best understood by referring to a diagram (*fig.* 10.), from which it will be seen, that the strata of red sandstone and magnesian limestone are not parallel to any of the subjacent beds.

The magnesian limestone is so durable a building-stone, that it has been selected, by a committee appointed to investigate the subject, for the construction of the new Houses of Parliament.

Rock-salt may be so easily recognised by its well-known taste, that it requires little more description; its structure is generally crystalline, and where this is perfect it may be split or cleaved into a cube, or right-angled parallelopiped.

The New Red Sandstone Formation, however interesting to the geologist, is poor in metallic minerals; but it affords the ores of zinc along the sides of the Mendip Hills, in Somerset, where a magnesian conglomerate separates the limestone from the red sandstone. Generally speaking, lighter and warmer colours prevail throughout this system than in the strata of the preceding ones.

The Oölitic System, as we proceed from west to east, succeeds to the saliferous; it is characterised by an almost total absence of metalliferous substances in the limestone strata, except where clay ironstone occurs in the beds termed *lias.* These are thin beds of argillaceous limestone (generally of a grey, yellowish, or bluish colour,) alternating with beds of clay in the lower part of the system. The iron-ore forms bands, or thin strata, in the upper portion of these beds.

The oölites, or roestones*, which give to this system its designation, differ greatly in their aspect from all the other limestones which we have mentioned: they consist of globular grains, cemented by a similar calcareous paste; these grains, when broken, and examined with a high magnifier, appear to be formed of concentric laminæ. The Bath stone, as before mentioned, is a good example of the roestone, and lies in the lower part of the series: a great part of the city of Oxford is built of the middle oölite, which is quarried at many places in Oxfordshire, Northamptonshire, and Rutland: and the Portland-stone, which is so much valued as a building-stone that it is carried into distant parts of the kingdom, is quarried in the upper oölite.

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* *From their* strong resemblance to a fish's roe.

The Lower Oölite Formation consists of several beds of limestone, some shelly, (including that called the Cornbrash and Forest Marble,) some argillaceous (lias limestone), and the Bath or the great oölite stratum; of marls and clays, including a limited bed of fullers' earth, (near Bath,) and a stratum of ferruginous sand resting immediately on the lias. Among the various beds of clay is one lying beneath the Portland oölite, which is of a dark bluish-grey colour, or nearly black, called Kimmeridge clay. It is apparent for a considerable distance along the coast, at the junction of Hampshire and Dorsetshire, where it contains shale, highly bituminous, so that it resembles a slaty coal of inferior quality. The upper lias clay and shale affords alum, and is extensively quarried at Whitby, on the coast of Yorkshire, for the purpose of obtaining this salt. When the shale has been exposed for some time to the atmosphere, the alum appears in the form of a delicate white efflorescence, which separates the laminæ, and at length causes the shale to fall to pieces. Alum is also worked from beds of alum shale at Hurlett and Campsie, near Glasgow. Both in the middle and lower oölite formations, the clay strata greatly exceed in thickness that of the limestone beds.

The uppermost portion of the oölitic system is called the Wealden formation; it is of much more limited extent than the strata of oölite and lias, occupying only a portion of Kent and Sussex, and the Isle of Wight. It consists of alternating beds of clay and sand, of which the uppermost is called the Weald clay, from the tract where it occurs. The lower part of this alternates with the Hastings sands, and includes the clay ironstone which is raised in Sussex. The lower stratum includes a bed of shelly limestone, known by the name of Purbeck marble. The Wealden formation is supposed to be an estuary deposit, the shells found in it being those which live in fresh or brackish water.

THE CRETACEOUS (CHALK) SYSTEM, resting upon the oölite, forms a long range of undulating hills, running beside the last-mentioned group, extending from the south part of Dorsetshire to the north of Norfolk, Lincoln, and Yorkshire, and occupying a portion of Hants, Sussex, Surrey, and Kent. In fact, the chalk formation may be said to occupy the south-eastern part of England, included between the oölitic range and the sea; but that it is partially covered, and to a very considerable depth, by the plastic and London clays, and other beds of the tertiary, or newer system. The chalk itself forms two beds; the upper one soft, containing very parallel and numerous layers of flint nodules, and great abundance of fossil remains, chiefly of zoophytes and echini, which exist in both these substances. The lower chalk is much harder, and not unfit for building,—a purpose for which it is frequently quarried; it contains generally fewer flints than the upper chalk, and is often of a greyish colour. Iron pyrites is plentifully sprinkled through both beds, but is not sufficiently abundant to make it an object of research in either. Beneath the chalk lies an argillaceous bed, called *chalk-marl,* resting on two beds of greensand; in the lower of these are local beds of fullers' earth, which has long been obtained from pits at Reigate, Nutfield, and other localities in Surrey, and at Woburn, in Bedfordshire. The lower greensand is a much more considerable stratum than the upper greensand, and in some parts forms hills which are nearly equal in altitude to those of the chalk range, as in the Weald of Surrey and Kent, and in the north-east of Ireland. These two strata are separated by a calcareous clay, called *gault,* which, as well as the greensand and chalk, is rich in fossil remains.

Above the chalk rests the TERTIARY SYSTEM, of which the different formations vary considerably in different parts of the world. In England, the lower part consists of the London and Plastic Clay formation, including several beds of sand, which is surmounted in Hants and the Isle of Wight by alternating freshwater and marine beds; and the uppermost, a deposit called *crag*, much more recent. The London and plastic clay strata extend over a large space on either side the Thames, from Dorchester to Essex and Kent. The London clay is generally of a bluish grey colour when first taken up, but when dry of a warmer tint: it is used in brickmaking, and the coarsest kinds of pottery. The Plastic clay formation contains detached beds of finer clay, as in Dorsetshire, where pipe-clay is dug, fit for the manufacture of white earthenware.

The beautifully coloured sands at Alum Bay, in the Isle of Wight, form a part of the London and Plastic clay formation, and the sand and gravel in the neighbourhood of London and Bagshot lying *upon* the London clay. In this stratum we find abundance of fossil shells, amounting to at least 240 species, and layers of flattened nodules of a round or oval shape, called *septaria:* these are argillo-ferruginous limestone, mostly of a dark brown colour, and intersected in various directions by veins of white calc-spar, more or less crystalline. (*fig.* 11.) When this substance is burnt it forms a cement, very extensively used, which hardens well under water.

Crag is a local deposit, peculiar to the coast of Norfolk, Suffolk, Essex, and probably a part of Yorkshire. It resembles a shingle beach, with layers of sand and shells intermixed, some of which are much worn, and the bones of fish, and occasionally of extinct large quadrupeds—the whole much stained by oxide of iron.

From the preceding sketch we learn, that metallic minerals exist more abundantly in the ancient than in the recent formations. We find also, that the granitic rocks, though less ancient than those called *primary*, (gneiss, mica-slate, clay-slate,) afford a greater variety of metals than any others. Not only copper, lead, tin, and iron, occur in this formation, but bismuth, antimony, nickel, titanium, molybdenum, uranium, tungsten, &c. Several of these have never been made applicable to any useful purpose; some, because from their natural qualities they are unfit to be manufactured; others, because their reduction to a metallic state is an operation of extreme difficulty, and some, perhaps, because they are not found in sufficient quantity. The latter circumstance has been the cause of many substances being neglected, till, accident having shown that they existed abundantly in other localities, they have since been manufactured for various useful or ornamental purposes. We may instance *chrome* as an example, which has been for some years obtained plentifully from the chromiferous iron of Norway: combined with lead, it produces the brilliant chrome yellow, at a very moderate expense; and its oxide, of a rich green colour, has greatly superseded the greens formerly in use for painting on porcelain, which were made from copper.

As we approach towards the newer formations, we find abundance of mineral riches, both earthy and metallic, of the most useful and even necessary kinds. Lead and zinc abound in the mountain limestone; iron in the coal formation of the same system; copper veins intersect the carboniferous limestone, as well as slate and granite; salt and gypsum are obtained from the strata of the New Red Sandstone formation, as well as the ores of cobalt, zinc, and copper; and the Old Red Sandstone affords the ores of zinc and manganese. Among these formations we find also building-stone and marbles.

Having thus given a slight geological sketch of the various strata of Great Britain, and of the general nature of the minerals which they are composed of, and which they afford, we proceed to describe the metallic ores, and some few other substances of general occurrence or utility: and as the object of this work is to direct attention principally to those which are useful rather than curious, we shall give the most detailed description of such as are met with plentifully in the British strata, or which might be valuable if found more abundantly.

The number of simple metals at present known is thirty-one*: their names are—

Platinum
Gold
Silver
Mercury
Copper
Lead
Tin
Iron
Zinc
Palladium
Nickel
Cadmium
Arsenic
Antimony
Selenium
Bismuth
Cobalt
Manganese
Tellurium
Titanium
Columbium
Molybdenum
Tungsten
Chrome
Osmium
Iridium
Rhodium
Uranium
Cerium
Bromium
Vanadium

The greater part of these are found in combination with sulphur, oxygen, chlorine, or some of the various acids; in which cases their appearance is often so totally different from that which they present in a state of purity, that a person having never seen them in any other, could not possibly recognise them. For instance, copper, in the state of carbonate, is a beautiful blue or green mineral, without any metallic lustre; sometimes regularly crystallised, sometimes having a concentric radiated structure. Lead, as a carbonate, is colourless, and, if pure and crystalline, is perfectly transparent, with a lustre equal, if not superior, to that of the diamond. Some metals are alloyed naturally together, preserving, in most respects, their usual metallic characters, such as their lustre, opacity, weight, &c.: others have never been known to form such combinations. In the greater number of cases, if a specimen of ore be characteristic, an accurate observation of its external characters will enable us to recognise it without having recourse to the assistance of any chemical process. It is not, however, to be understood, that the first time a person totally unacquainted with the subject meets with a well-marked specimen he will, certainly, be able, by reference to a collection of minerals, or a treatise on mineralogy, to ascertain to what species it belongs. It cannot be expected that such accuracy of observation and comparison is to be attained without some practical study and experience.

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* We except the metals which are the bases of the earths and alkalies, which are never called *ores*, since the metals themselves are never to be found in nature; nor can they be made use of except in the earthy form.

These characters or properties by which minerals may be distinguished are necessarily somewhat numerous, as some or other of them belong to all known mineral species, of which there are several hundred. Like the terms of botany, and other branches of natural history, the words by which these characters are defined are, to a certain degree, technical; it is necessary that they should be so, in order that the same words may always convey the same ideas, and that thus every one, in giving the description of a mineral, may be equally intelligible.

The following list comprehends all the characters or qualities to which we have adverted:—

- Form:
  - Regular,or crystalline
  - Irregular or accidental
- Structure, or texture:
  - Regular, or cleavage
  - Irregular
  - Form of fracture.
- Optical characters:
  - Simple refraction
  - Double refraction
  - Transparency
  - Colour
  - Lustre
  - *Phosphorescence.*
- Hardness.
- Tenacity.
- Flexibility.
- Elasticity.
- Specific gravity.
- Odour.
- Taste.
- Adhesiveness to the tongue.
- Action on the touch.
- Electricity.
- Magnetism.

It will readily be perceived that some of these characters are of little importance in comparison with others, as they belong to but a few species: such are odour and taste; while form, texture, colour, weight, &c., which are essential to all, require to be farther particularised.

As these explanations may appear too uninteresting to the student to engage his attention, we will proceed to the descriptions of mineral species, and place this explanatory chapter at the end: but he will probably soon find that he will have frequent occasion to refer to it.

The chemical characters of minerals are still more important than those which are evident to the sight or touch, inasmuch as they relate to their *composition*, and therefore mark the real difference between substances which may have, *externally*, so much resemblance as to render it difficult to distinguish them by other than chemical examination. The chemical analysis of minerals is, however, a matter of considerable difficulty, and requires a good deal of apparatus, with which it would be inconvenient to travel; but many ores may be partially assayed, and the nature of a great number of metallic (and also other) minerals ascertained, by some chemical experiments which require but a few drops of acid and that useful little instrument, the blowpipe. Its object is to increase and concentrate the heat of a flame, by supplying it with a constant stream of air in one direction,—the more steady and uniform the better. Various machines have been invented to produce this effect, but the most simple, and by far the most useful to the mineralogist, is that which is furnished with air from the lungs. It may be made of brass, silver, or platinum, and may be either a simple bent tube, or be furnished with a globular cavity near the middle of its length, to condense and retain the moisture of the breath. (*figs.* 12, 13.) To use this with facility, though not very difficult, requires some practice. Any one who has been accustomed to play on the flute (or other wind instrument) will find it easy to produce a steady flame by means of the blowpipe, since it is necessary to supply the draught of air, not immediately from the lungs, but by means of the mouth; otherwise it would be incessantly impeded by the act of respiration, and the action of the flame on any substance under examination as frequently interrupted. The mouth should, therefore, become a reservoir of air which must never be allowed to become exhausted.

A small lamp, fed either with oil or melted tallow, is, perhaps, the best adapted for the exercise of the blowpipe, but a wax candle with a large wick, or even a tallow one, answers extremely well, and the latter has at least the advantage of being always within reach.

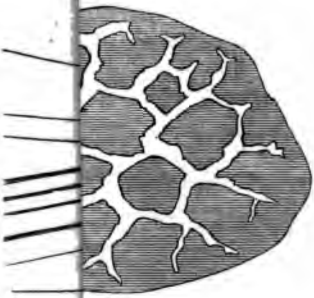
As soon as the operator can produce a steady flame with this instrument, he will perceive that it now consists of two parts,—the outer one yellow, the inner blue: the heat of the latter is the most intense, and frequently produces fusion on substances which will not melt in the outer flame. It is better, however, to expose the mineral at first to the lesser degree of heat, and approach it afterwards to the blue or reducing flame. In most cases, it is desirable that as small a quantity as possible should be examined; a specimen from the size of a grain of mustard-seed to that of a pepper-corn is quite sufficient. When it is suspected that the substance to be examined is a metallic oxide, it is advisable to place it on a piece of charcoal, sufficiently compact, in which a small hollow may be scraped, to prevent it from being displaced on its first exposure to the draught of air. In other cases, a small platinum spoon, or forceps of the same metal, may be made use of.

Platinum is employed for these purposes on account of its extreme infusibility, and it has the advantage of being a bad conductor of heat, for which reason it is preferable to silver, which is also made use of for such supports; small slips of platinum foil will sometimes be found useful. If the mineral be in a state of powder, or should it be advisable to pulverise it, it may still be safely placed on the charcoal by mixing it with a drop of wax or tallow, which will keep it in its place, and then quickly burn away. The platinum spoon and foil are to be used, when it is necessary to add a flux to the mineral under consideration: this will often receive a colour from the oxidised metal, which is characteristic of it, as blue from cobalt, green from copper, &c. Some minerals, both metallic and earthy ones, fuse into a bead of perfect glass, without the addition of a flux: some ores produce a slag, or dark-coloured opaque glass, others into a sort of enamel, intermediate between glass and porcelain; others, again, become a scoria, or cindery matter. We ought not only to observe these results, but the manner in which they take place, as, whether the substance froths and swells during fusion, (fusing with intumescence,) whether it melts slowly or rapidly, whether its colour changes, and if the smell of arsenic or sulphur is perceptible.

In subjecting minerals to the action of an acid, we observe whether they are soluble, whether the solution is slow or rapid, and whether it is accompanied by effervescence. These effects do not always take place at the common temperature of the air; in this case the mineral may be pulverised, and with the acid be exposed to a gentle heat. An experiment of this kind may be made on a very small scale, which will afford the most satisfactory results. A watch-glass is well adapted for containing the small quantity of mineral which is necessary; and if additional heat be required, a piece of bent wire will form a very good support, on which it may be held over the flame of a candle or lamp. (*fig.* 14.) If solution takes place, the addition of a drop of some chemical re-agent will in many cases produce a precipitate, in others, a change in the colour of the solution, which will characterise the presence of some particular metal.

Plate II.

To face p. 42.



g. 11.

Fig. 14.

Fig. 15

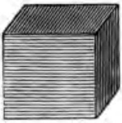


Fig. 18.

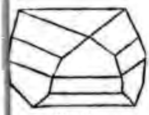


Fig. 21.

GOLD.

Gold has never been found otherwise than in the metallic state — sometimes very nearly pure, but always, in fact, alloyed with some proportion of silver, which varies from the smallest fraction to 72 per cent.

Metals, when found in a metallic and nearly pure state, are called *native metals;* and gold is termed native gold, when the quantity of silver it contains is but small, and does not alter its general appearance, which resembles that of the gold of commerce. Its colour and hardness are the same, (except when, in consequence of containing a larger proportion of silver, the colour is somewhat paler,) but it is less heavy. The specific gravity of pure melted gold is 19·25, but that of native gold is considerably less, varying from 12·66 to 14·7. This difference may arise, not only from the variable proportion of silver, and occasionally a minute quantity of other metals which it contains, but perhaps from its being less dense in a crystallised state*, than after the process of fusion. When the proportion of silver is somewhat larger, it is termed argentiferous native gold, and when the quantity of silver exceeds that of the gold, the alloy may with propriety be termed auriferous silver.

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* It will be remembered that ice (crystallised water) is

Gold is sometimes found crystallised, and, like other native metals, its crystals belong to the cubic system; but other forms also occur, which are not referable to the regular solids, being prismatic, with oblique terminations. Its most usual forms are the cube with its angles or its edges truncated. (*figs.* 1. to 8.) The surface of the crystals is seldom quite smooth, and they have scarcely any lustre, resembling what is called *dead gold* in ornamental work; but the crystallised gold-sand, which is obtained from some of the rivers of South America, is sometimes extremely brilliant. Crystals of gold, however, are comparatively scarce: it is much more usually found disseminated through quartz, the vein-stone or matrix in which it generally occurs, in small irregular lumps and grains, or wiry filaments; or it assumes the form of moss and lichen, or it forms

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considerably lighter than fluid water;—a fact sufficiently proved by its always floating when not attached to any fixed object.

tufts of imperfect crystals, partially filling the cavities of veins. In the beds of rivers, also, it is intermixed with common sand and pebbles, in the shape of irregular grains of different sizes: it has been found in this manner in the stream-works of Cornwall, mixed with the tin ore and alluvial matter which accompany it in such localities, and a specimen of this kind is said to have been once found in that county about the weight of two ounces and a half. Gold is said also to have been observed imbedded in quartz in the refuse of a mine called the Prince-Regent, in the parish of North Moulton, in Devonshire.

Gold has been obtained from alluvial soil both in Scotland (at Lead Hills, and Glen Turret in Perthshire,) and in Ireland; in the latter county at one time to the amount of a thousand ounces in the county of Wicklow;—it was intermixed with quartz, oxide of iron, and wolfram. Thus it appears that this metal occurs in materials of very different ages, though it is probable that in most alluvial situations the sand and earth which accompany it are the debris of the older rocks, the original repositories of gold.

At present more gold is obtained from the sand of the rivers in South America than from any other source. The gold of Africa is found in a similar situation, and many rivers of Asia afford small quantities of this metal. But in seeking for gold in such repositories, we should observe whether the rivers take their rise in a mountainous country, and especially to what formation of rocks those mountains belong.

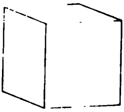
Gold is fusible before the blowpipe, and after fusion appears in the form of a globule, the colour being deeper or paler, according to the quantity of silver with which it is alloyed. It is insoluble in every acid except the hydrochloric, commonly called *aqua regia* (a mixture of the nitric and muriatic acids), from which any silver it contains will be precipitated in the form of chloruret, forming a white cloud. If chloruret of tin be added to the solution it will become purple, and a precipitate of the same colour will fall to the bottom of the glass.

Gold has within a recent period been discovered in Merionethshire, in a number of veins near Dolgelly, which traverse the Cambrian slate formation. It exists in sufficient quantity to render the working of it tolerably profitable, independently of the other ores, especially argentiferous galena, which are found in the vicinity. The gold is disseminated in small particles, so as to form a sort of partial coating on quartz, and is intermixed in smaller quantity, in other parts of the veins, with oxide of iron, iron pyrites, and decomposing blende; and sometimes it occurs in interlacing fibres.

The greater part of these veins are very small, varying from the eighth of an inch to six inches in width, but in some parts they enlarge to the width of two or three yards. They are most productive at the parts where they intersect the more ancient veins, of which there are two series; the older ones affording argentiferous galena, with copper ore and blende, in a vein-stone of quartz; the more recent ones (intersecting them,) are generally filled with carbonate of lime and sulphate of barytes, with galena and blende. Both the lead veins and the gold veins are richest in ore at the points of intersection—a circumstance which is frequently observed in the veins of Cornwall. At the East Cwmheisian mines, from 2 to 20 ounces of gold are obtained from a ton of washed ore, and at the Berthllwyd mine, the produce of the auriferous veins has amounted to 59 oz. 5 dwts. per ton of ore; while the average produce of the gold ore, both in Siberia and South America, is said to be generally under one ounce per ton.

This discovery will no doubt lead to a more careful investigation of other similar veins, or such as are similarly situated, and probably to the discovery of other repositories of this valuable metal.

Plate 3.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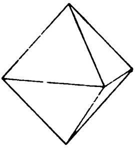
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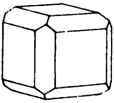
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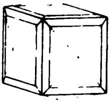
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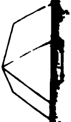

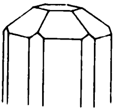
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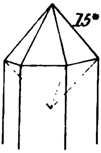
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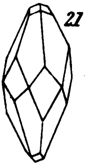
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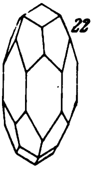
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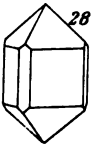
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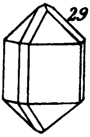
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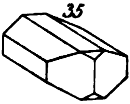
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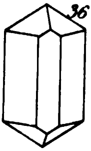
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SILVER.

THIS metal occurs in many different states; like gold, it is found native, and very abundantly; it is also mineralised by various substances. Its ores are—

- Alloys:
  - Native silver
  - Auriferous silver
  - Antimonial silver.
- Sulphurets:
  - Silver-glance (simple sulphuret)
  - Antimonial sulphurets
  - Arsenical sulphurets
  - Cupreous sulphuret.
- Seleniuret.
- Chloruret.
- Carbonate.

NATIVE SILVER.

When first taken from the mine or vein, it is in general perfectly white, having in every respect the characters of pure silver; but by exposure to the air it becomes tarnished, first of a yellow colour, afterwards grey, and sometimes black, as we see with plate which has been neglected. If, therefore, we find a specimen which from other circumstances we think may be silver, it will be well to scratch it; the streak will distinguish it from some other metals; for it happens sometimes that in parts of veins where there are cavities, especially in those which lie near the surface of the earth, or which have been worked, the silver is much exposed to the action of the air. Like the silver of commerce, it is malleable, ductile, and soft, though somewhat harder than gold. Its crystals belong to the cubic system; they are most frequently octahedral, and are often aggregated together in a peculiar manner, forming branches at right angles to each other, not unlike some kinds of fir trees.* Sometimes it is found in solid masses of considerable size, and often in other accidental forms, such as bent filaments and moss-like tufts; but the latter will be often found, by the assistance of a magnifier, to consist of minute crystals. The specific gravity of silver, when pure, is 10·47: that of native silver varies a little. It is fusible by the blowpipe at a less heat than gold, affording a bead of pure silver. It is soluble in nitric acid; and if a piece of perfectly clean copper be dipped into the solution, a film of silver will in a few seconds be deposited on it. This test of the presence of silver is equally applicable to the solution of its other ores; and will serve also to detect it, if existing in the ores of other metals.

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* The native silver of Norway frequently occurs in this form, imbedded in, or lying in the cavities of, white quartz.

ANTIMONIAL SILVER.

We have already mentioned that silver is frequently combined in nature with gold; the combination of silver with antimony is found occasionally with other of its ores, filling small veins, or in small irregular masses and grains, of a silver-white colour, and with the same metallic lustre as silver itself. It is easily distinguished, however, from the native metal, by subjecting it to the action of the blowpipe: the antimony is volatilised by the heat in the form of a white vapour, and a bead of silver will result. When this substance is crystallised, it takes the form of a rectangular prism, of which sometimes the lateral, sometimes the terminal edges, and sometimes the angles, are modified. Specific gravity 9·44.

SULPHURET OF SILVER. (*Silver Glance; Vitreous Silver Ore; Glanzerz; Silberglanz; Argyrose.*)

This mineral has apparently no resemblance to metallic silver; being of a dark grey colour, and externally sometimes black: when broken the fracture is uneven, or small conchoidal, with a lustre which is only semi-metallic. Its crystallisations belong to the cubic system, and its most usual forms exhibit the planes of the cube and octahedron (*fig.* 7.), and sometimes the same faces combined with those of the rhombohedron. (*fig.* 10.) It also forms considerable masses in those countries where silver ores are abundant, and is the substance from which the principal part of the silver of commerce is obtained. It is soft, sectile, and somewhat malleable; characters which distinguish it from some other sulphurets, which have some resemblance to it when the crystallisation is indistinct. Its specific gravity varies from 6·9 to 7·2.

When sulphuret of silver is subjected to the action of the blowpipe, it melts, giving off sulphureous vapours, and forming at first a scoria; but after being exposed for some time to the heat of the reducing flame, it affords a bead of pure silver.

ANTIMONIAL SULPHURET OF SILVER.

There are several combinations of silver with sulphur and antimony, and also with sulphur and arsenic, which have been much confounded together, notwithstanding their difference of composition, and in some a difference of crystallisation: this has arisen from a considerable similarity in their chemical characters, and probably also from the indistinctness of the crystals of many of the specimens examined. We shall endeavour to particularise those which it will be useful to recognise.

LIGHT RED SILVER ORE. (*Rubinblende; Red Sulphuret of Silver.*)

Under this name are comprised two distinct species: the one an antimonial (argyrythrose of Beudant), the other an arsenical (Proustite) sulphuret of silver. The colour of both minerals is a fine ruby red: their lustre vitreous in specimens which are transparent; but in some, where the colour is darker, the lustre approaches to semi-metallic. The crystals are derived from obtuse rhomboids: the angles (inclinations of the planes) of the primary rhomboid of the antimonial sulphuret are 108° 30′, and 71° 30′, and those of the arsenical sulphuret differ very little from them. The crystals are similar to many of the forms common to the carbonate of lime; but they are always small, sometimes minute; often much heaped together, and occasionally rounded, so as to become indistinct.

The larger ones, however, may with care be split in directions parallel to the faces of the primary rhomboid. (*figs.* 11. 21, 22, 23.) The specific gravity of the antimonial red silver ore is 5·8 or 5·9; that of the arsenical 5·2 to 5·5. They are soft and brittle, being easily scratched by a knife, and even by fluor-spar, which is much less hard, and reduced to powder which is a clear bright red. Both species are fusible by the blowpipe, and a globule of silver is the result. In the outer flame, the antimony of the one becomes a white vapour, and the arsenic of the other is perceptible by its strong smell of garlic. They are soluble in nitric acid, the solution depositing silver on a copper wire or plate immersed in it. This deposition of silver on copper, from its solution, is always a test of the presence of the former metal.

DARK RED SILVER ORE. (*Argent Antimonié Sulfuré noir; Rothgültigerz; Myargyrite* of Beudant.)

This mineral is of a much darker colour than the last species; so that many specimens appear quite black, with a semi-metallic lustre: but small fragments held between the eye and the light transmit a deep-red colour. The crystals are derivable from an oblique rhombic prism, the lateral planes meeting at angles of 93° 56′ and 86° 4′, and the inclination of the same edges to the base being 101° 6′. It is brittle, the fracture conchoidal, and the powder deep red: specific gravity 5·2 to 5·4.

The chemical characters are the same as of the last species, except that the antimonial vapour produced by the action of the blowpipe is more abundant in the dark-red silver ore.

BRITTLE SILVER GLANCE. (*Argent Antimonié Sulfuré noir; Psaturose,* Beudant; *Sprödglanzerz; Schwartzgültigerz.*)

It will be seen, by the synonymes which we have given, that this species has been confounded with the preceding one, although its crystallisations are derived from *right* a rhombic prism; and it has been mistaken also for the following substance (polybasite), of which the crystals are hexagonal. The crystals of the brittle silver glance are generally small and indistinct; and it is sometimes, like the other species, massive, or disseminated among the vein-stone. It contains a much larger proportion of silver than the dark red ore, affording from 60 to 70 per cent., while the former yields only about 36, and the light-red species (antimonial) 58 per cent. The specific gravity of brittle silver glance* varies from 5·9 to 6·2, and its powder is black. Chemical characters like those of the two preceding minerals, except that sometimes the odour of arsenic is perceptible when it is placed before the blowpipe in the oxidating flame, arising from an occasional intermixture of the sulphuret of arsenic.

POLYBASITE. (*Brittle Silver Glance,* in part; *Bournonite,* in part.)

There is still another sulphuret, which contains a large proportion of silver, with a smaller quantity of antimony, and the addition of some copper and arsenic. The globule of silver obtained by fusion is considerable, in proportion to the specimen assayed; if this be dissolved in nitric acid, the solution will become blue on the addition of ammonia. The lustre of this mineral is more decidedly metallic than that of the preceding species: colour, both when massive and powdered, iron-grey: crystals, the regular hexagonal prism. Specimens of this ore appear to have been mistaken for Bournonite (sulphuret of antimony, lead, and copper), for the dark-red silver ore, and for grey copper ore (*Fahlerz*): they all have a considerable resemblance when seen only in small disseminated masses, or indistinctly crystallised. We have, however, given the chemical tests for recognising the presence of silver and copper, which are the points most essential to be ascertained.

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* A name well adapted to distinguish this species; since most of the antimonial sulphurets are brittle, and this particularly so.

CUPREOUS SULPHURET OF SILVER. (*Stromeÿerine; Sulphuret of Silver and Copper.*)

A metallic substance of a steel-grey colour and splendent lustre, very tender, and brittle,—the form of the fracture imperfectly conchoidal. Soluble in nitric acid: the solution precipitating a film of copper on a plate or wire of iron immersed in it; and again depositing silver if copper be dipped into it. Fusible by the blowpipe, without forming a scoria or increasing in size.

Of all these sulphurets, the silver glance and the light-red silver ore are the most abundant. The former occurs in most of the great natural repositories of silver. It has been found in several veins, both in Cornwall and Devonshire, accompanied by native silver, and sometimes by some of its other ores: crystallised, in the cross vein of Herland mine;

with native and red silver in Wheal Duchy; in Wheal St. Vincent, near Callington; in a copper vein of Dolcoath mine: native silver has been raised also in Wheal Mexico. Both there and in Wheal Basset it is associated with argentiferous galena: the latter and Herland are the richest silver mines in the county. In some mines the native and other silver ores have been found intermixed with red oxide and green carbonate of copper; in other veins with arsenical cobalt and copper pyrites. Silver ores are extensively worked in Saxony and Bohemia: in the former country the veins traverse gneiss; in the latter, mica-slate and clay-slate: in the Hartz the rock is principally grauwacké, and in Lower Austria the veins intersect a mountain limestone. The red silver ore (argyrythrose) is found in many of the localities of silver glance;—in considerable quantity at Kongsberg in Norway, Joachimsthal in Bohemia, Schemnitz in Hungary, Ste. Marie aux Mines, Vosges, the Hartz Forest, &c.; but in some of the Mexican and Peruvian mines it is the principal ore. Most of the remaining species are at present matters of curiosity to collectors of minerals; but should they be found in larger quantity, they might equally well be smelted with the others.

SELENIURET OF SILVER.

It is described as being of a lead-grey colour, metallic, and crystallised in small tabular hexagonal crystals. It has been found among the ores of Tasco in Mexico.

EUKAIRITE. (*Seleniuret of Silver and Copper.*)

The only place in which this mineral has as yet been found, is the mine of Skriekerum in Smoland. It is of a lead-grey colour, with a metallic lustre; is malleable and sectile, fusible before the blowpipe, exhaling a pungent vapour, which is the volatilised selenium: this character, therefore, is common to this and the foregoing species: the globule which results is brittle, and of a grey colour.

CHLORURET OF SILVER. (*Chloride of Silver; Muriate of Silver; Horn Silver Ore; Kerargyre.*)

A non-metallic substance, generally white, or having a greyish or yellowish tinge, semi-transparent, of a waxy or horny texture, sectile, and becomes shining where it is cut; massive, or disseminated amongst other substances, but rarely crystallised: its forms are cubic and octahedral. Specific gravity, from 4·7 to 5·5. It is fusible before the blowpipe, but reducible with difficulty to the metallic state without the addition of a flux. When rubbed on a clean surface of iron or copper, it deposits metallic silver.

Although this mineral is of rare occurrence in Europe, it is very abundant in Mexico, where it is much intermixed with the hydrate of iron (brown ironstone), and pierced by innumerable threads of native silver, forming the ores called *Pacos* and *Colorados.* It is there worked with advantage as a silver ore.

It has been found in very small quantity in the mines Wheal Mexico in Cornwall, and Wheal St. Vincent near Calstock in Devonshire.

CARBONATE OF SILVER.

Hitherto this mineral has been observed only in the mine of Wenceslaus, at Atwolfalch in Baden. It is described as being of a light-grey colour, lustre metallic, fracture fine-grained, sectile, becoming more shining where it is cut or scratched: reducible without difficulty by the blowpipe to a globule of pure silver.

Besides all these ores of silver, this metal is often combined with the ores of other metals, as galena (sulphuret of lead), the alloys of tellurium, gold, &c. These can scarcely with propriety be termed ores of silver; yet they are frequently smelted for the silver they contain, as are some of the ores of tellurium for the sake of the gold they afford: from one of these gold is obtained to the amount of 30 per cent. The argentiferous galena is one of the most profitable ores of Cornwall, being smelted advantageously for both metals.

ANALYSES OF SILVER ORES.

	Auriferous Silver.[1]	Antimonial Silver.[2]	Eukairite.[3]	Silver Glance.[3]	Light Red Silver Ore (Antimon.)[4]	Light Red Silver Ore (Arsenical).[5]	Dark Red Silver Ore.[5]	Brittle Silver Glance (Psatur.)[5]	Cupreous Sulphuret of Silver [6]
Silver	72	77	38·93	86·5	58·94	64·67	36·40	68·54	52·87
Gold	28	—	—	—	—	—	—	—	—
Antimony	—	23	—	—	22·84	0·69	39·14	14·58	—
Arsenic	—	—	—	—	—	15·09	—	—	0·34
Iron	—	—	—	—	—	—	0·62	—	—
Copper	—	—	23·05	—	—	—	1·06	0·64	30·83
Selenium	—	—	25·	—	—	—	—	—	—
Sulphur	—	—	—	13·5	16·61	19·51	21·95	16·42	15·96
Earthy matter	—	—	8·90	—	0·30	—	—	—	—
Carbonic acid and loss	—	—	3·12	Loss.	1·31	—	—	—	—

[1] Fordyce. [2] Klaproth. [3] Berzelius. [4] Bonsdorff. [5] H. Rose. [6] Stromeyer.

COPPER.

THE ores of copper are as numerous and more widely distributed than those of silver. They are found in primary, secondary, and granitic rocks; sometimes at great depths, but occasionally very near the surface of the earth: their existence may often be suspected from the green stains which prevail on the rocks and stones in their vicinity, as at the Parys Mine in Anglesea, where a bluish-green colour seems to pervade the whole country around.

Copper occurs as a native metal, and mineralised by sulphur, oxygen, silica, chlorine, and various acids.

- Alloys:
    - Native copper.
- Sulphurets:
    - Copper glance
    - Phillipsite
    - Copper pyrites
    - Grey copper ore
    - Tennantite.
- Chloruret.
- Oxydes:
    - Red copper, (protoxide)
    - Black copper ore.

- Carbonate:
    - Anhydrous carbonate
    - Green carbonate (malachite)
    - Blue carbonate (azurite).
- Silicate.
- Sulphate.
- Phosphate.
- Arseniate (oliven ore):
    - Rhomboidal
    - Octahedral
    - Oblique prismatic
    - Right prismatic.

NATIVE COPPER.

It is so nearly pure, that it presents all the usual characters of pure copper; is malleable, ductile, and somewhat harder than silver. The specific gravity of native copper is somewhat less than that of the melted metal, varying from 7·7 to 8·3; that of copper is 8·8. It does not occur in such large masses as native silver, but is usually distributed in various dendritic or branching forms or leaves, and irregular plates, in the quartz, or whatever other mineral may form the matrix. Sometimes, but not very frequently, it is crystallised, and, in common with other native metals, its forms belong to the cubic system: the octahedron, however, occurs more often than the cube, and sometimes the angles, sometimes the edges, are truncated: but good crystals of this metal are rare, and it does not present many modifications. The surface both of crystallised and uncrystallised specimens is often tarnished with a brown or yellowish tint, and sometimes is thinly coated by green carbonate of copper, with which both the native copper and the red oxide are often much intermixed. It is soluble in nitric acid with effervescence, the solution becoming blue by the addition of ammonia, a circumstance which characterises the presence of copper generally when in solution. Before the blowpipe it is fused without difficulty into a bead of copper, tinging the flame green during fusion.

COPPER GLANCE. (*Vitreous Copper Ore; Sulphuret of Copper; Chalkosine.*)

This mineral is of a dark steel-grey colour, and when freshly broken, has a perfectly metallic lustre; but externally it is dull and generally black, unless varied by an iridescent tarnish. Its crystals belong to the rhomboidal system; and the most usual forms are, a low hexagonal prism, of which the terminal edges are replaced by single planes; a similar prism terminated by pyramids; and a solid, composed of portions of two double six-sided pyramids. (*figs.* 14.

16, 17.) More complex crystals sometimes occur, but they are rare. It may be cleaved parallel to the base of the prism; and also in three other directions, parallel to the planes of an acute rhomboid, but with some difficulty: the fracture is generally conchoidal. But it is mostly found in amorphous masses, to which crystals are sometimes attached, either filling the vein, or intermixed with the veinstone. In Cornwall, the principal veinstone of the copper mines is fluor spar, of a pale green colour, and perfectly crystalline structure, which is made use of as a flux in the smelting of the copper ores. Copper glance is soft and sectile, but its softness is not uniform; which may arise from an occasional combination of a small portion of copper pyrites. When it is exposed to the action of the blowpipe, it appears at first to boil and froth, and after a time becomes a grey globule: if this be again melted with soda, the glassy matter which results will be found to contain minute grains of copper, soluble in nitric acid.

Of all the sulphurets of copper, this is the richest in metal, containing 75 per cent. of copper, and no other metal. It is commonly called *grey copper* by the miners of Cornwall; but it must by no means be confounded with the grey copper ore of mineralogists

(*Fahlerz* of the Germans), which is often found in the same mining district, and is a much less profitable ore.

PHILLIPSITE. (*Variegated Copper Ore; Variegated Copper Pyrites; Buntkupfererz.*)

This is a double sulphuret of copper and iron, and was for a long time considered to be a variety of copper pyrites, which it resembles in composition, but the proportions of the three elementary substances differ in the two species. Its lustre is perfectly metallic, and internally the colour is browner than that of copper; but the surface, both of the crystals and of the mammellated variety, generally exhibits a beautiful iridescent tarnish, in which a bright purple colour predominates. Its crystals are generally cubes, having the angles replaced by a single plane, and it sometimes forms a coating on the tabular hexagonal crystals of copper glance. It is often disseminated in irregular masses among quartz, carbonate of lime, and other minerals, but which are generally small. It is softer than copper pyrites, and somewhat brittle, and less easily fusible than copper glance. The globule which first results is attractable by the magnet: on a second fusion with soda, small globules of copper will be visible in the glassy matter which is produced. When dissolved in nitric acid, if ammonia be added, a precipitate of oxide of iron will take place.

COPPER PYRITES. (*Yellow Copper Ore; Chalkopyrite.*)

This is the most abundant of the English copper ores, and a very productive one, though it contains less copper than the Phillipsite, affording about 31 per cent. of metal. Its colour is that of brass, with a perfectly metallic lustre, and when broken it has an uneven fracture. It is found in masses of various dimensions, from a grain to some hundred pounds in weight, occasionally filling the whole space of the vein in which it occurs. Imperfect or indistinct crystals are not uncommon, but finely crystallised specimens are scarce. Some very fine specimens of crystallised copper pyrites have been raised from the Derbyshire mines: the form is a tetrahedron, of which the edges are generally truncated. (*figs.* 3. 7.) This tetrahedron differs very little from the regular one (of the cubic system), but is in reality referable to an octahedron with a square base.*

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* The two pyramids of this octahedron meet at an angle of 102° 30′. The planes of the regular octahedron meet at an angle of 109° 28′ 16″.

There is a good deal of similarity between copper pyrites and iron pyrites, but the former has a brighter colour and is less hard; and its specific gravity, which is 4·16, is rather less than that of iron pyrites. It is a mineral of such universal occurrence, that there are few ores with which it is not occasionally found intermixed. Blende and Galena are frequently accompanied by it, as well as the other ores of copper: in the latter case, if it be constant, it is presumable that there may be entire veins of it in the neighbourhood.

Grey Copper Ore. (*Fahlerz.*)

A less abundant ore than the preceding, but equally rich in copper. In some localities it contains silver, of which the proportion is variable: when the quantity is sufficient to repay the trouble of a double process, it is smelted with advantage for both metals. It is probable that several species are still included under this name, bearing great resemblance to each other in form, colour, hardness, &c., but differing considerably in composition. The mineral to which the name properly applies, is a sulphuret of copper and antimony, with a small per-centage of iron and zinc: some varieties contain 10 per cent., some less, of arsenic; and others, as before observed, silver. Among all these constituents, the sulphur is the only one which is tolerably constant in its proportion; so that we may consider *Fahlerz* to include a group of sulphurets, with variable bases.* At Freyberg and in some of the mines in the Hartz Forest, silver has been obtained from ores of this kind, to the amount of 31 per cent.

Grey copper ore is of a light steel-grey colour, with a bright metallic lustre; crystallisations, the regular tetrahedron, simple and modified on the angles and edges. (*figs.* 3. 7.) The specific gravity, owing to the variable nature of its composition, ranges from 4·79 to 5·10. The blowpipe produces similar results to those obtained from copper pyrites, but the presence of antimony or arsenic, or both, will be detected by the vapour which is evolved previously to fusion. We have already mentioned the mode of discovering the presence of silver, copper, and iron in these ores, when dissolved by nitric acid, in which all these sulphurets are more or less soluble.

The different varieties of grey copper are all of a lighter colour, harder, and more brittle than the copper glance; characters which may serve to distinguish the two species when the crystallisation is not visible. These ores sometimes occupy considerable depositaries alone, or nearly so; and in other localities we find them in small veins amongst the veins of other ores, or intermixed with them in cavities.

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* Beudant has therefore given it the name of Panabase.

TENNANTITE.—BOURNONITE. (*Endellione.*)

The former a sulphuret of copper and arsenic; the latter, a sulphuret of copper, antimony, and lead. They are both at present scarce minerals. The tennantite occurs in small brilliant crystals, having the form of the rhombohedron, of which the angles are generally truncated, and quite black. The crystals of Bournonite are derived from a right rectangular prism; but generally exhibit numerous modifications; and, being very small and brilliant, it is somewhat difficult to recognise their primary form.

Tennantite, before the blowpipe, gives off a strong odour of arsenic, and burns: Bournonite affords, at first, a yellow oxide; and, on further reduction, a globule of copper. The former mineral appears to be peculiar to Cornwall; but Bournonite occurs in the copper district of the Hartz, and in the neighbourhood of lead ores in some few other localities as well as in Cornwall (Tencroft, Dolcoath, Wheal Boys).

RED OXIDE OF COPPER. (*Ruby Copper; Red Copper Ore; Tile Ore.*)

With native copper (and occasionally with the other ores of this metal) we often find small brilliant crystals and granular masses of a fine ruby colour, which are more or less transparent, or only translucent, and when broken appear to have a vitreous lustre and conchoidal fracture: these are the protoxide of copper. It is abundant in some of the Cornish mines, and has been found in considerable quantity in other localities; but it does not, like the sulphurets, occur in masses. Its crystallisations, of which the octahedron may be considered the primary form, are very numerous; but in most, the face of the octahedron are discernible. (*figs.* 2. 6. 10.) One of the most beautiful varieties is that which occurs in delicate capillary crystals, crossing each other at right angles, which are in fact slender square prisms. Specific gravity, 5·3 to 5·6: its hardness is rather greater than that of red silver ore; but it may be scratched by fluor spar.

TILE ORE.

This is an impure variety of the red oxide of copper, being much intermixed with oxide of iron and earthy matter, which render it brownish, opaque, and compact, in the harder varieties; in other specimens, earthy. It occurs in thin flattish masses, somewhat resembling dark-coloured tiles.

Fusible into a black scoria, and reducible to a globule of copper.

CARBONATE OF COPPER.

Of this there are three species: the anhydrous carbonate (that which contains no water in its composition) has hitherto been observed only in India. It is a compact substance, of a blackish-brown colour when [pure, but often stained with green or reddish brown. Fracture, small conchoidal; sectile, but tender; lustre non-metallic; specific gravity 2·62. It occurs in small rounded masses in the older rocks of the Mysore district.

MALACHITE. (*Green Carbonate of Copper.*)

This name has sometimes been applied exclusively to the green carbonate of copper, which has a fibrous and radiated structure; but it belongs equally to the other varieties of the same species. Crystals of malachite are rare (*fig.* 34.); they are derived from a right rhombic prism, of which the angles of the base (or the inclinations of the lateral planes) are 103° and 77°.* The finest have been obtained from the copper mines of the Oural Mountains: more usually it forms pencils of acicular divergent fibres, and it is often earthy, or intimately mixed with the earthy matter which forms the matrix of the red oxide and other ores of copper. It has no metallic lustre; and, except the acicular variety, is opaque and dull, the structure varying from fibrous to compact. The compact malachite forms roundish and kidney-form masses of various sizes, from that of a nut to a foot or more in diameter; and when broken they exhibit concentric layers of various and distinct shades of pure green (*fig.*16.). This is the kind used for ornamental purposes: it is abundant in Siberia, but does not appear to have been raised from the English copper mines, unless in some very few small specimens. Its specific gravity is 3·5, and in hardness it is intermediate between calc-spar and fluor-spar: this, however, can apply only to the crystallised and compact malachite, since the acicular crystals are too slender and fragile, and the earthy kind too incoherent, to exhibit their real hardness.

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* The octahedral crystals of malachite, and those in the form of a slightly oblique rhombic prism, arise from decomposition; the former from the red oxide, the latter from the blue carbonate of copper; and a portion of the original matter is sometimes found in the interior of them.

BLUE CARBONATE OF COPPER. (*Azure Copper Ore; Azurite.*)

This very beautiful mineral is of a dark purple blue, without any metallic lustre, and when pure is semi-transparent. It is generally crystallised, unless when it is impure and occurs of a somewhat earthy texture. The crystals are oblique rhombic prisms, generally having the acute angles or the terminal edges truncated. (*figs.* 40, 41.) They are generally aggregated into small roundish masses, which are sometimes quite globular, and free from any mixture of earthy matter or other ores. Specific gravity 3·0 to 3·8. Like Malachite, when heated in a closed vessel, the water it contains becomes perceptible, and it blackens. They are both soluble in nitric acid, with effervescence.

Both these minerals are found in numerous localities, but there are few where they are so abundant as to be the principal object of exploration. Large quantities of malachite, however, are raised in Siberia and Hungary: in England it is an ore of no importance, but occurs occasionally in the Cornish copper-mines, and the lead-mines of Cumberland and Caernarvon. The blue carbonate abounds at Chessy, near Lyons, where it is converted into the sulphate of copper, a mode of working it which appears to have been found more profitable than the process of smelting it for copper. In England it has been found in very small quantity, and in but few localities.

SILICEOUS CARBONATE OF COPPER. (*Chrysocolle.*)

It is of a somewhat bluer tint than malachite, with a resinous and sometimes vitreous lustre when broken. It is found sometimes intermixed with malachite, from which it may be distinguished by its different lustre, and often by a slight degree of transparency: sometimes it forms a coating on malachite or other copper ores. It varies in its appearance, even in the same specimen; for one part may be hard enough to scratch glass, brittle, vitreous, and semi-transparent, green, and occasionally brown; while in another part it is earthy, opaque, and dull.

DIOPTASE. (*Silicate of Copper; Copper Emerald.*)

The brilliant emerald-green colour and its transparency distinguish this mineral from all other copper ores. It has been found only crystallised, in the form of hexagonal prisms, with rhombic terminations; but it has not yet been met with in Great Britain; and the preceding species is also of rare occurrence in this country. Both are infusible before the blowpipe, without the addition of a flux, which will be coloured green by the operation.

ARSENIATES OF COPPER.

WE are acquainted with four different species of arseniate of copper, two of which appear to be peculiar to Cornwall; but as they are all unfit for the purpose of smelting, we shall notice them merely as affording indications of the probable existence of other ores of copper in the neighbourhood where they may be observed.

OCTAHEDRAL ARSENIATE.

Colour pale blue, greenish blue, or bluish white; translucent; crystallising in obtuse octahedrons having a square base (*fig.* 25.); the terminal edges are sometimes truncated; fracture vitreous; specific gravity 2·88.

RHOMBOIDAL ARSENIATE. (*Copper Mica.*)

The latter name has been given to this mineral from its occurring in thin transparent brilliant plates, of a deep green colour, resembling in form crystallised mica (*fig.* 12.). These are not, however, prismatic crystals, but sections of a very acute rhomboid. Both these minerals give off water when heated, and are reducible by the blowpipe to white metallic globules, attackable by nitric acid.

RIGHT PRISMATIC ARSENIATE. (*Oliven Ore.*)

The crystals of this mineral, which are always very small, are of an olive-green colour, sometimes so deep as to appear quite black, but occasionally pale yellowish green or yellowish brown. The pale colours, however, are more characteristic of the fibrous varieties (which, in fact, consist of delicate acicular crystals); these have a silky lustre; and some, which are more compact, and of a brown tint, have received the name of wood copper: specific gravity 4·28. This species does not appear to contain any water in its composition; but phosphoric acid has sometimes been detected in the analysis. The globule obtained by fusion is surrounded by a black glassy scoria.

OBLIQUE PRISMATIC ARSENIATE. (*Trihedral Oliven Ore.*)

Although the crystals of this mineral belong to the system of the oblique rhombic prism, we most frequently find it in small octahedrons, which are portions of the primary solid (*fig.* 17.). Sometimes only the trihedral points of the rhomboid are apparent, covering a considerable space; whence it obtained the name *trihedral* oliven ore. The globule obtained by fusion from this species crystallises to a certain degree in cooling.

All the species are characterised by the smell of arsenic, which becomes perceptible when they are exposed to heat; to observe this, it is sufficient to powder a small quantity and throw it on hot coals.

SULPHATE OF COPPER.

This mineral is not often found in a solid state: it [illegible] from the decomposition of copper pyrites and the other cupreous sulphurets; and being very soluble, it is dissolved and washed away by the water of the mines into streams and pools; whence it is removed to cisterns, and either evaporated to produce the solid sulphate of copper, or the metal is obtained from it by throwing in old iron, on which the copper is deposited in a metallic state. Both these processes are pursued at the Parys Mine, Anglesea, where the existence of the copper ore was discovered by the circumstance of a horse refusing to drink at a stream running below the rock, in which the mine was afterwards excavated. The water being tasted, was found unfit to drink, and upon examination it proved to be strongly impregnated with sulphate of copper.

In a solid state this mineral is of a fine blue or bluish-green colour, semi-transparent, vitreous, and very brittle.

PHOSPHATE OF COPPER.

Two species are known, but they have been found in extremely small quantity, and in few localities. That which crystallises in rectangular octahedrons has been met with in Cornwall, among other ores of copper. The colour of both is dark-olive or blackish green, with bright surfaces.

CHLORURET OF COPPER (*Muriate of Copper; Atakamite;*)

Has been found hitherto only in Peru, associated with silver ores, and in very minute crystals, mixed with the sand of the river Lipas, running through the desert of Atakama, between Peru and Chili. Its colour is a bright grass-green.

All these three species are reducible by the blowpipe, with the addition of soda, to a metallic globule; but they have not been found in sufficient quantity to be made use of.

ANALYSES OF COPPER ORES.

	Copper Glance.[1] & [2]		Variegated Copper Ore.	Copper Pyrites.[4]	Grey Copper Ore.[4]		Tennantite[3]	Bournoni.[5]
Copper - - -	76·50	79·50	61·07	34·40	25·23	38·42	45·32	13·
Sulphur - -	22·	19·	23·75	35·87	23·52	25·03	28·74	20·
Iron - - -	0·50	0·75	14·	30·47	3·72	1·52	9·26	—
Antimony - -	—	—	—	—	26·63	25·27	—	25·
Arsenic - - -	—	—	—	—	—	2·26	11·48	—
Silver - - -	—	—	—	—	17·71	0·83	Lead.	41·
Zinc - - -	—	—	—	—	3·10	6·85	—	—
Earthy matter - -	—	1·	0·50	—	—	—	—	—
Loss - - -	—	—	0·68	—	—	—	—	—

[1] Klaproth. [2] Ullmann. [3] R. Phillips. [4] H. Rose. [5] Smithson.

IRON.

IRON has been found in several places as a native metal; but beneath the surface of the earth, its existence in this state is rare; it is disseminated only in small particles or thin veins among iron pyrites and hydrate of iron; or contained in some of the lavas both of recent and extinct volcanoes.

The large masses of native iron with which we are acquainted, are so singular both in their situation and external appearance, that they are now considered to be incontestably of meteoric origin. Whatever may have been the mode of their formation, or their former position, there can be little doubt that they have fallen from the atmosphere to our earth. The times at which some of them have fallen, have been accurately recorded*; but of others, such as the immense mass near Jenissek in Siberia, that at the

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* In 1751, on the 26th of May, a mass of iron fell to the earth at Agram in Croatia, at six o'clock in the evening; at Lahore in Hindostan, the 17th of April 1621; in Lucania, fifty-two or fifty-six years before the Christian era; and we have many authentic accounts of the fall of meteoric stones of various sizes, sometimes singly, sometimes in showers, which all contain nickeliferous iron.

Cape of Good Hope, and many more, in various parts of the globe, we have no account beyond a description of their size and general appearance, which is that of an irregular mass of iron, much corroded and oxidated by exposure to the air. They are quite malleable when nearly pure; but all meteoric iron contains a proportion of nickel, which is sometimes sufficient to render it rather brittle, Infusible by the blowpipe. Specific gravity, 6·4 to 7·8.

The ores of iron are:—

- Alloys:
  - Native iron.
- Sulphurets.
- Oxides.
- Hydrate.
- Carbonate.
- Sulphate.
- Chromate.
- Phosphate.
- Arseniate

SULPHURETS.

IRON PYRITES (*Martial Pyrites; Marcassite;*)

Is of a pale golden yellow colour, but much less bright than copper pyrites. It is sometimes massive, forming considerable veins, and very frequently crystallised. Its crystals belong to the cubic system, and it is one of the few minerals which assume the forms of the pentagonal dodecahedron[*] and icosahedron (*figs.* 4, 5.): octahedral crystals are not very common. The cubes of iron pyrites, and other substances which crystallise in these forms, are often striated in a peculiar manner, parallel to those edges of the dodecahedron which lie in the same directions (*fig.* 18.).[†] It is considerably harder than copper pyrites; is scratched with some difficulty by a knife, and will strike fire with steel. It is of such universal occurrence, that to particularise its localities or the different strata in which it is found abundantly, would be, in the first case impossible, and in the last needless. It is not made use of, as other ores of iron, for the purpose of smelting; but is either decomposed by exposure to the atmosphere and moisture, and thus converted into sulphate (green vitriol), or the sulphur is obtained from it by means of heat.

The nodules of iron pyrites, which are abundant in the chalk strata, consist of fibres radiating from the centre; the exterior is often deep brown, and when broken exhibits an earthy texture, the result of decomposition: sometimes the points of octohedral crystals appear on the surface.

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[*] It must be observed that the dodecahedron of iron pyrites differs a little in its angles from the regular one, which is classed among the platonic solids.

[†] The references to figures, from this page to the end of the work, refer to Plate III., except *fig.* 19. in p. 100., and *fig.* 20. p. 107., which refer to Plate II.

MAGNETIC PYRITES. (*Hepatic Pyrites.*)

This is a much scarcer mineral than the preceding. It contains a smaller proportion of sulphur than the common iron pyrites, and affects the magnetic needle. The colour is a reddish bronze, with a metallic lustre, and when crystallised it takes the form of an hexagonal prism, of which the terminal edges or angles are generally truncated. (*fig.* 15.)

ARSENICAL IRON PYRITES. (*Arsenical Iron; Mispikel.*)

The arsenical pyrites occurs in many of the localities of tin ore, both in Cornwall and other countries. Unfortunately, it is altogether unprofitable; and we describe it, that it may not be mistaken for any other substance, as it is always carefully separated from the ores with which it is found, before they are smelted. Its colour is white, or yellowish white, sometimes inclining to grey; the lustre metallic; and it is either disseminated in small masses, or crystallised in short rhombic prisms, variously modified, chiefly on the angles. (*figs.* 38, 39.) Like iron pyrites, it is hard enough to give sparks with steel; but when struck, the odour of arsenic is perceptible. Its specific gravity is 6·1, while that of iron pyrites does not exceed 5.

By exposure to the action of the blowpipe we obtain a metallic globule, which is attractable by the magnet.

OXIDES.

(MAGNETIC IRON ORE. (*Loadstone; Natural Magnet.*)

WE are acquainted with but two species of oxide of iron, though the varieties of one of them (red oxide) are very numerous, and have at different times been named as distinct species. The magnetic iron (which is the least oxidated) is of rare occurrence in Great Britain. Its colour is dark steel-grey, with a metallic or semi-metallic lustre; and when crushed, the powder is nearly black. It forms, in some countries, immense masses and thick veins, but is sometimes crystallised in the form of the regular octahedron, the same solid with its edges replaced, and the rhombohedron (*figs.* 2. 9, 10.): specific gravity 4·7 to 5. Small crystals have been found sparingly imbedded in serpentine, in Unst, one of the Shetland Isles, in some parts of Cornwall and Devon, and at the gold mines of Wicklow in Ireland. In the latter place, it occurs in the alluvial soil; but it is most abundant in the older crystalline rocks, such as gneiss, and more particularly, mica schist; and it is much disseminated through the rocks which consist principally of horblende and serpentine. No large masses of the magnetic iron ore are known in England; but in Sweden and Norway, the greater part of the mountains at Dannemora, Nordmarker, Arendal, &c. consist of it.

This ore not only affects the magnetic needle, but is itself magnetic, possessing whether in large or small masses, a north and south pole; and it will retain by attraction objects made of iron and steel.

It is an excellent and profitable ore for smelting, when found in large quantities, being very free from extraneous substances; and is said to be more advantageous for the production of steel than of bar iron.

Blende, galena, pyrites, and garnets are often found with magnetic iron ore; the latter sometimes imbedded in it.

RED OXIDE OF IRON. (*Peroxide of Iron.*)

The varieties of this oxide are so different in their appearance, that at first sight it would appear impossible that they should be the same substance, differing only in their mode of aggregation.

SPECULAR IRON (*Iron Glance; Oligiste Iron;*)

Is the red oxide in a pure and crystalline state. The crystals are black or dark steel-grey externally, and very splendent; or they have a beautiful iridescent tarnish. The most beautiful specimens of this kind are brought from the Island of Elba, where there are very extensive and ancient mines of it. When broken, the colour is dark steel-grey, and the lustre brilliant; but when powdered, the colour of all varieties of this species, whether crystallised or otherwise, is deep blood-red; and thin fragments or plates, held between the eye and the light, transmit the same colour. The crystals are derivable from a slightly acute rhomboid: some are very complicated, others are so thin and flat that they resemble scales of mica. In the latter form, specular iron has been found in Perthshire, and also near Tavistock in Devonshire. Some specimens of this ore affect the magnet; but this character is by no means constant. Specific gravity about 5.

RED IRONSTONE; RED HÆMATITE; RED IRON OCHRE.

These are all varieties of the same oxide, and are found in great plenty in several parts of England, forming large and small veins in the mountain limestone, and, more seldom, thin beds in the same formation.

Red ironstone is compact, of a colour intermediate between brick-red and blood-red, opaque and without lustre: some varieties incline to steel-grey, and these have a slightly glimmering lustre, as if from an intermixture of metallic powder. Hæmatite is the same mineral, with a compactly radiated structure. In this form it is known to many persons, being used to make burnishers for polishing the gilding on porcelain and other substances. Both these kinds are less hard than the specular or crystallised red oxide, being scratched without difficulty by a good knife.

With these varieties we often find red ochre, which is the red oxide of iron intermixed with a considerable proportion of clay; it is much softer, of lower specific gravity, and lighter colour. Red chalk is the same mineral. At Ulverstone in Lancashire all these kinds of red iron ore, except the specular iron, are found in a vein of immense thickness, which traverses the mountain limestone. In Lanarkshire the ironstone vein intersects a sandstone belonging to the same formation; near Edinburgh this ore is found in greenstone, (at Salisbury Crag); and in Cornwall, at Botallack Mine, near the Land's End, in slate, but not abundantly. In many other countries it is extensively worked; more often in the secondary limestone, (mountain limestone), and other formations of nearly the same period, but occasionally in older rocks.

These ores may be easily distinguished from the red silver and red copper ores, by their infusibility when exposed without addition to the action of the blowpipe.

HYDRATE OF IRON. (*Brown Hæmatite; Brown Ironstone; Bog Ore; Morass Ore.*)

It is but lately that the brown ironstone and hæmatite have been worked as iron ore in England, though in France they have long been smelted in large quantities. This may perhaps have arisen from its being found much less abundantly in this country than other profitable ores. At present, however, in the eastern part of Cornwall, where it is plentiful, it is raised for the forge; though formerly it was thrown aside, as not being worth the process necessary for its reduction.

The brown hæmatite resembles the red hæmatite in its structure, exhibiting, when broken, a radiated fibrous fracture, but it has a silky lustre. It occurs in nodules and kidney-form masses; also in stalactites and tubes, which are found pendent in the cavities of veins. The general colour is a coffee-brown; but near the exterior, which is very dark, sometimes black and shining, there is often a band of a lighter and yellower colour: sometimes there are two or three of these bands; and they are always very parallel, following the undulations of the surface. It is softer and more brittle than the red hæmatite, and not quite so heavy.

Brown ironstone bears the same relation to this mineral that red ironstone does to red hæmatite. It is more or less compact, according to its purity, containing sometimes a small proportion of clay and silex. The powder of both varieties is yellow.

Yellow ochre is another state of hydrate of iron;

sometimes pure, sometimes combined with alumina or hydrate of alumina. When free from any intermixture of other substances, it is collected for the purpose of manufacturing the colour so named. Near Shotover Hill in Oxfordshire, it is obtained from the lower bed of the greensand formation, lying under the lias limestone; and it has been found abundantly in parts of some of the copper veins in Cornwall.

There are some other varieties of hydrate of iron, called pea-iron ore (Bohnerz), bog ore, morass ore, and meadow ore. They are all capable of being smelted; and in some parts of Europe a good deal of iron is obtained from them; but in Great Britain they are found but in few localities, and not very abundantly. One of the principal depositories in this country is the morass at the foot of the Cheviot Hills: they occur also in some parts of the Highlands of Scotland, in the Shetlands and Orkneys. Their colour varies from yellowish to blackish-brown, and the texture from compact to friable, with a dull earthy fracture. Those varieties which are the most compact generally contain numerous cavities, sometimes lined with the same substance in the state of powder.

The pea-iron ore, which is abundant in the Jura

Mountains and some other parts of the Continent, consists, as its name implies, of small globular masses, which are compressed together, and cemented by the same substance: their texture varies from compact to earthy or even friable. It contains 30 or more per cent. of alumina, intermixed with the hydrate of iron. It forms extensive beds in some countries.

All the different kinds of hydrate of iron are characterised by affording water when calcined, and by their producing, when melted with borax, a dull-green glass, containing metallic globules, attractable by the magnet.

CARBONATES.

CARBONATE OF IRON. (*Sparry Iron Ore; Brown Spar; Clay Iron Ore; Clay Ironstone.*)

WHEN pure, carbonate of iron is white, and crystallises in the form of an obtuse rhomb, differing very slightly from that of carbonate of lime and some other solids of the rhombic system; but it presents few modifications. (*figs.* 11, 12. 18.) In Cornwall it has been found in hexagonal prisms of a wax-yellow colour, from half an inch to three quarters in diameter, and in very obtuse small rhomboids of a pure white; but in this state it is scarce. A less pure variety with a lamellar or crystalline structure, generally of a brown colour, is found in considerable quantity in some localities, in detached masses, and filling small veins in various strata, sometimes in the slates of the primary system, but more often in the secondary rocks, particularly those belonging to the coal formation and mountain limestone. This variety, as well as the crystallised carbonate of iron, very much resembles calc-spar in its external appearance, but it may be distinguished by its greater weight, (the specific gravity of brown spar is from 3·4 to 3·8, that of calc-spar not more than 2·7,) by its effervescing more slowly when a drop of hydrochloric or nitric acid is applied to it, and by the different results obtained by the blowpipe: calc-spar becomes perfectly white, being converted into quick lime; but carbonate of iron blackens, and becomes attractable by the magnet.

The lamellar variety has long been smelted in France, though it is by no means plentiful in England; while, on the other hand, the French have, until recently, neglected a very useful though less pure ore, which supplies a great part of the English furnaces, the

CLAY IRON ORE.

This is the carbonate of iron intermixed with a considerable proportion of earthy matter, and presenting no outward appearance of being a metallic mineral, resembling rather an indurated clay of a dull yellowish-grey colour, sometimes passing to a dirty brown, or a bluish grey, which is occasionally very dark. Its texture is earthy, more or less compact, and breaking generally with an even fracture, which is sometimes slightly conchoidal. Sometimes it has a slaty structure, which is particularly the case with the tabular masses. They are occasionally very large, and lie in a parallel direction one to another, forming extensive beds between the sandstones of the coal formation. The nodules also, which are of various forms and dimensions, are not imbedded indiscriminately; neither do they fill veins, like other ores; but clay ironstone seems to form a part of the system of strata in which it occurs; and where the bed is not continuous, the interstices are filled with *shale. The* nodules are sometimes kidney-shaped, sometimes having the form of oblate spheroids; and they frequently contain impressions of plants, particularly of reeds and ferns, which are found also in the sandstones contiguous to them. They sometimes split readily in the direction of these leaves or branches, exhibiting an impression on either side. Petrified shells also are abundant in the clay ironstone of some localities; as in some parts of Derbyshire, where the ore is of a brown colour, and the shells nearly black.

Clay ironstone is not confined entirely to the strata of the coal formation; it is found in the Wealden sand, and considerable quantities are raised in Sussex.

The composition of clay ironstone varies exceedingly: in some instances it contains sixty per cent. of carbonate of iron; in others, not more than twenty-two; the remainder being a variable mixture of alumina, silica, and the carbonates of lime, magnesia, and manganese.

Sulphate of Iron, (*Green Vitriol,*)

Like sulphate of copper, is produced by the decomposition of *pyrites*, and particularly of the white iron pyrites. Small quantities of it are found in many of the localities where that mineral is abundant, either in small masses, in the form of stalactites, or as an efflorescence. Its colour is generally green, if the substance be pure; but in situations where it has been exposed to the action of the atmosphere it is often yellow or brownish. It is rarely crystallised, and is seldom found in sufficient quantity to be collected separately; but is prepared artificially from iron pyrites, by causing it to decompose. It is very soluble, and may easily be recognised by its metallic and styptic taste.

CHROMITE OF IRON.

From this mineral chromate of potash is manufactured, which is employed in the preparation of chromate of lead, commonly known by the name of chrome yellow: the chrome green, which is used for painting on porcelain, is also obtained from it.

Its colour is black, with a metallic lustre; and when crystallised it takes the form of the regular octahedron. In these points it has some resemblance to the native magnetic iron; but the chromite of iron does not affect the magnetic needle until it has been exposed to the blowpipe; which, however, does not reduce it without addition. When it is melted with potash, it becomes soluble in water, and the solution will be of a fine orange colour. It is harder than glass.

Hitherto this mineral has been found in very small quantity in the British Isles; and in but few localities, namely, Portsoy in Banff, and two of the Shetlands, Unst and Fetlar. In all these places it occurs in serpentine, its most usual repository in other countries. It is found in France and several other European territories, in Siberia, and North America.

PHOSPHATE OF IRON. (*Vivianite.*)

This is a rare mineral, and has not at present been applied to any use. In Cornwall and Derbyshire it occurs in transparent prismatic crystals, of a fine blue colour, which are sometimes two inches in length, sometimes very small and slender, forming small groups in the cavities of pyrites or shale.

ARSENIATE OF IRON.

It occurs in very small cubic crystals of a dark olive-green colour, with (generally) a shining surface, attached to brown hæmatite or the copper ores. It is of no utility, but we mention it on account of its being associated with other ores, which belong to the primary and granitic rocks, and of which it may probably be an indication.

TIN.

THE only natural combinations of this metal at present known, are — the oxide, from which all the tin of commerce is obtained; and a sulphuret combined with copper, which has been found in very small quantity.

TIN PYRITES. (*Sulphuret of Tin; Bell-metal Ore.*)

Colour varying from steel-grey to yellowish or reddish white; lustre perfectly metallic; fracture fine granular, sometimes approaching to the conchoidal form; specific gravity, 4·3 to 4·7; fusible by the blowpipe, depositing a white powder on the charcoal, which is not volatile: this is the oxide of tin.

In Huel Rock (parish of St. Agnes, Cornwall,) it was found partially filling a vein of considerable width, with blende and iron pyrites.

OXIDE OF TIN. (*Tin-stone; Stream-tin; Wood-tin.*)

It is most usually crystallised or granular; sometimes massive, with numerous small cavities. When granular, it is much intermixed with the vein-stone, and the minute crystals are often thickly imbedded in it, while the larger ones generally line the cavities of the veins.

The crystals are square prisms, terminated by pyramids, of which the edges are often replaced (*figs.* 27, 28, 29.); but it is seldom that more than one termination is visible. It presents also other modifications, but they are much less common than these forms. Maculed or twin crystals (*fig.* 19.) are also frequently met with.

The crystals are mostly very small, but they are occasionally an inch or more in length. Its most common colour is dark brown, but crystals are sometimes met with yellowish, or even colourless, and transparent; the darker varieties are semi-transparent, and the black ones opaque. Externally the crystals are generally shining; and the lustre of the fracture is brilliant: when scratched or pulverised, the powder is white: it is sufficiently hard to give sparks with steel, but brittle; and the specific gravity is as high as 6·5 to 6·9; which is remarkable, being nearly as great as that of pure tin.

These ores belong to the oldest formations of rocks. In England the tin veins appear to be confined to the granite and clay-slate of Cornwall; and in other countries they traverse the same rocks, and also gneiss and mica-slate; but they have rarely been observed in those strata which are the great repositories of lead and silver ores. The vein-stones of tin are generally white quartz and chlorite; and many other crystallised minerals are found with it, as fluor-spar, topaz (the latter particularly in Saxony, and occasionally in Cornwall), schorl, actinolite, phosphate of lime, iron and copper pyrites, and blende. It may be observed that the ore of tin is generally found nearer to the surface of the earth in Cornwall than the ores of copper.

STREAM-TIN.

In the beds of streams in those countries where tin veins occur, rolled masses of oxide of tin, and grains of various sizes, are often found intermixed with fragments of rock, pebbles, and sand; the whole rounded by attrition. These are collected for the purpose of smelting, and the diluvial matter with which the ore is intermixed is separated from it by washing in a stream of water, which is made to pass over it. The places where this operation is performed are called *stream-works,* and the ore so collected, *stream-tin.* Such deposits are met with, not only in Cornwall, but in Chili and some other localities. In these situations grains of native gold are generally found intermixed with the tin ore; and small quantities of granular tin-stone have been observed amongst the alluvial gold of Wicklow.

WOOD-TIN.

This is a fibrous variety of the same substance, which occurs in the form of pebbles, and reniform or somewhat globular masses of rather a larger size, in the stream works of Cornwall. It is very similar, both in its colour and structure, to the brown hæmatite, having internally the same radiated fibrous appearance, though more compact, and with less lustre, and the same concentric shades of dark and yellowish brown. Wherever these two varieties may be observed, it will be well to explore the neighbouring rocks from which the stream descends, as it is probable that tin veins will be discovered at no great distance.

The granite and slate of Cornwall contain one of the greatest known deposits of tin ore, which has been explored from a very early period. A great part of the armour of the ancient Greeks, which was a compound of tin and copper, was fabricated with the tin of Cornwall. No tin-stone, however, has yet been observed in the granite of Scotland.

LEAD.

THERE are many natural combinations of this metal, and a great part of them are found in Great Britain; but one only is principally used as an ore for smelting — the sulphuret, or galena. We say *principally*, because the carbonate and other combinations often occur in small quantity with it, and are not rejected.

The following table exhibits its various ores:—

- Alloy:
  - Native lead.
- Sulphuret:
  - Galena.
    - —— argentiferous
    - —— antimonial.
- Oxides:
  - Yellow oxide
  - Red oxide.
- Chloride:
  - Corneous lead ore.
- Carbonate.
- Sulphato-carbonate.
- Sulphate.
- Phosphate.
- Arseniate.
- Chromate.
- Tungstate.
- Molybdate.

NATIVE LEAD.

Has hitherto been found only in small particles in some of the substances ejected from volcanoes, and still more rarely, forming slender prisms in masses of galena. It has all the characters of pure lead, is very fusible, malleable, soluble in nitric acid, and on immersing a plate of zinc in the solution, a film of lead will be deposited on it; but no precipitation takes place on the immersion of copper, which distinguishes this metal from silver.

GALENA. (*Sulphuret of Lead; Lead Glance.*)

This ore is very widely distributed through various formations, from the oldest of the primary rocks to the newer secondary ones.

It is a mineral easily recognised, whether crystallised or amorphous: in the former case, it offers some of the forms belonging to the cubic system; most usually, the cube with its angles truncated (*figs.* 1. 6.); more seldom, the cube with the edges replaced by one plane (*fig.* 8.), or by two. (*fig.* 8*.)

The crystals are often dull externally; but when broken, the fracture is very brilliant, with a perfectly metallic lustre, and the cleavages are always parallel to the faces of the cube. It is very brittle, so much so that cleavages may generally be obtained by a slight blow, or even by dropping a piece on the floor. The same crystalline structure prevails where there is no regular external form, as when the galena entirely fills the vein. But this sort of crystallisation is often interrupted, so as to produce a sort of granular structure, similar to that of Parian or Carrara marble:

occasionally, it is fine-grained, granular and rarely compact: in the latter variety there is not much lustre.

The specific gravity of galena is 7·75; it is easily fusible by the blowpipe, giving off sulphureous vapour. Its solution in nitric acid will precipitate a film of lead on zinc, when immersed in it. If precipitation takes place also on the immersion of copper, the galena contains a portion of sulphuret of silver; and if, on exposure to the blowpipe, white vapour is disengaged, it is evident that some sulphuret of antimony is combined with it.

The vein-stone of galena varies in different localities, and in the different strata. In Derbyshire, Leicestershire, and other places, where the lead veins traverse the mountain limestone, the vein-stone is generally carbonate of lime or sulphate of baryte, affording beautiful specimens of calc-spar and fluor-spar. The metallic minerals, which are most commonly associated with it in these veins, are copper pyrites and blende; sometimes, also, iron pyrites and carbonate of iron. The crystals occur in the cavities of the larger veins, and one specimen of moderate size often exhibits several of the above-named substances. In Cornwall and Devonshire, where the lead veins traverse granite and slate, the galena is accompanied by quartz and fluor-spar. In the north of England and the lead mines of Lanarkshire, carbonate and sulphate of barytes are the prevailing vein-stones.

Oxides of Lead.

Both the yellow, or protoxide, and the red, or peroxide of lead, are very rare in nature: they have been observed occasionally, in the form of powder, in some mines, associated with other ores of lead. Both species are reducible with the greatest ease when exposed on charcoal to the blowpipe; the latter would be easily recognised by its well-known colour. If found in any considerable quantity, they would be most valuable ores.

Carbonate of Lead. (*White Lead Ore.*)

When crystallised, this mineral is perfectly transparent, and is remarkable for its great brilliancy, which, owing to its high refractive power, is equal, if not superior, to that of the diamond. The crystals are of very various forms, derivable from a right rhombic prism (*figs.* 31, 32, 33.); many of the simple ones are tabular (*fig.* 32.), but from the aggregation of several, an hexagonal prism results, terminated by pyramids (*fig.* 33.), very similar to the common crystal of quartz (rock crystal); but the hexagonal base differs from the regular figure, the angles not being all equal. It occurs also in a columnar or bacillar form, having a silky lustre, but nearly opaque, and the fibres are more often parallel than diverging (Pl. II. *fig.* 20.); sometimes in acicular crystals. Copper pyrites and blende are frequently intermixed with it; and in Cornwall it is associated with sulphuret of antimony, iron pyrites, and other ores and minerals peculiar to the rocks of that district.

Sometimes it is massive and crystalline, without any regular form, breaking either in large flakes or with a fracture which is either uneven or conchoidal, but always with a brilliant lustre. In the Durham and Derbyshire lead mines an earthy variety is abundant. This kind is somewhat like chalk, but generally less compact, sometimes even friable, and often stained with green or reddish-brown, by copper or oxide of iron.

Carbonate of lead may be distinguished from most earthy minerals by its great weight, its specific gravity being 6·7; the only one which is sufficiently heavy to be at first glance mistaken for it, is the sulphate of baryte, or heavy spar, which is very common in the lead mines of the north of England, Shropshire, and Wales; but they may readily be distinguished by the effervescence of carbonate of lead, on the application of nitric or hydrochloric acid. All the varieties of this ore are easily reducible by the blowpipe to the metallic state; and as they contain above 70 per cent. of pure lead, are very profitable for smelting.

The sulphato-carbonate of lead, which very much resembles the pure carbonate, is a scarce substance, which has been found crystallised in the mines of the Lead Hills in Lanarkshire. It effervesces much more feebly with acids than the carbonate of lead.

SULPHATE OF LEAD (*Lead Vitriol*)

Generally occurs in small crystals, colourless or yellowish, transparent or translucent, derived from a right rhombic prism: more seldom, it is massive, with a lamellar or crystalline structure, and considerable lustre. It is softer than the carbonate, and will not effervesce on the application of acid. It was discovered in the Parys copper mine, Anglesea; the crystals attached to a cellular ochrey mineral, of a dark brown colour.

PHOSPHATE OF LEAD. (*Green Lead Ore.*)

This is by no means a common mineral in the lead mines of Great Britain. It is generally of a beautiful light warm green colour; sometimes yellowish or brownish; opaque, or nearly so; and crystallised in six-sided prisms, which are often modified by small planes on all the edges; sometimes having pyramidal terminations (*figs.* 14, 15, 15*.); but they are mostly very small, or even so minute as to produce the appearance of moss.

The blowpipe has a very singular effect on this mineral: it fuses into a dark-coloured globule, which, on cooling, assumes a polyhedral form: on re-melting this with borax, small globules of lead will be perceived in the glass so produced.

ARSENIATE, CHROMATE, TUNGSTATE, MOLYBDATE, CHLORIDE, OF LEAD.

All these minerals are at present very scarce substances, valuable merely as cabinet specimens: we will, however, briefly describe them, as, if they should hereafter be found abundantly, it is probable that some at least might be very profitable, especially the chromate.

CHROMATE OF LEAD.

We have already noticed that this substance is prepared in laboratories with the chromic acid obtained from the chromite of iron, and is of a rich yellow or orange colour: the natural crystals are so deep-coloured as to approach to scarlet; but, when pulverised, the powder is yellow. The crystals are small rhombic prisms, of which the base is very nearly a square: these are terminated either by two or four planes. It has been found hitherto only in Siberia and Brazil, with galena and quartz, and sometimes phosphate of lead.

ARSENIATE OF LEAD.

It is of a pale reddish or yellowish brown colour, and occurs in the form of very small hexagonal prisms, which appear to consist of silky fibres, fasciculated together; sometimes also it is mammillated and compact; generally translucent; tender, but harder than calc-spar; soluble in nitric acid; reducible on charcoal by the blowpipe, giving off arsenical vapour. Found in some of the Cornish mines with red oxide and other ores of copper, and in the Beeralston lead mines, Devonshire.

Tungstate of Lead.

Found hitherto only in Bohemia: its existence even is said to be doubtful, and that a variety of the brown phosphate has been mistaken for this substance.

Molybdate of Lead.

This mineral occurs in small crystals, which are square octahedrons, both acute and obtuse (more frequently the latter), variously modified (*figs.* 25, 26.), of the colour of bees' wax, or a paler yellow; translucent, soft, and brittle: melted with borax it forms a brownish globule, and with a larger quantity, a greenish-blue glass.

Chloride of Lead. (*Muriate, or Murio-carbonate of Lead.*)

The crystals of this mineral are colourless or yellowish, and transparent, with considerable lustre: it is soft and sectile, resembling in its texture the chloride of silver; specific gravity, 6.; reducible, with some difficulty, alone by the blowpipe: with soda it readily affords globules of lead.

In England it has been found in the lead mines of the Mendip Hills, Somerset; and at Cromford, near Matlock, accompanied by galena, carbonate of lead, and fluor.

ZINC.

ZINC is not an abundant metal, although one of its ores (blende), like iron pyrites, is widely distributed. It has never been met with in the metallic state, either pure or alloyed with other metals. Its ores are —

Sulphuret (blende).
Red oxyde.
Carbonate (calamine).
Sulphate (white vitriol).
Silicate (electric calamine).

BLENDE.

In its purest state, blende is of a yellow colour, with a greenish tinge; but it is generally combined with more or less sulphuret of iron, which renders it brown, dark reddish brown, sometimes garnet red, and even black. The yellow blende is semi-transparent, and, in thin fragments, sometimes quite transparent; the darker varieties translucent, or nearly opaque: when massive it is generally brown. It has considerable lustre, but not of the metallic kind, and breaks with very distinct cleavages, parallel to the faces of the regular octahedron. Some other cleavages may be obtained, but with less facility. When crystallised, its most usual form is the rhombohedron (*fig.* 9.), which is often modified by small triangular planes, replacing some of the angles or edges. The crystals are of various sizes, from a pin's head to a small nut; and their faces, especially those of the smaller ones, are frequently convex, and generally brilliant. Its specific gravity is 4·16.

Blende is not reducible by simple exposure to the blowpipe, and is only partially soluble in nitric acid. When pulverised, and digested in sulphuric acid, a sulphureous odour is perceptible.

This ore does not, like the sulphurets of lead and copper, occupy large deposits alone: it is principally distributed among other ores, particularly those of lead. In the lead mines of Derbyshire, the north of England, and Scotland, it is abundant; and we have already remarked that the specimens affording crystals of galena are very frequently sprinkled with those of blende: the massive blende and massive galena are also much intermixed. It is found in considerable quantity in some of the tin and copper veins of Cornwall, whence finely crystallised specimens have been obtained.

Formerly blende was thrown aside with the veinstone, as an unprofitable mineral, all the zinc of commerce being obtained from calamine; but, for several years past, it has been employed advantageously for the same purpose.

RED OXIDE OF ZINC.

A mineral of a ruby-red colour, which occurs intermixed with, and imbedded in the oxidulous iron of some parts of North America (New Jersey, and near Sparta). It is massive, granular, or micaceous; the structure lamellar, and affording cleavages parallel to the faces of the regular hexagonal prism; translucent, brittle, easily scratched with a knife; specific gravity, 5·43; infusible without addition; but when mixed with carbonate of soda, it fuses into a transparent yellow bead. It has not yet been met with in Great Britain, but would undoubtedly be a valuable discovery, since it contains 88 per cent. of oxide of zinc, the remaining 12 per cent. being the red oxide of manganese.

CALAMINE. (*Carbonate of Zinc ; Lapis Calaminaris.*)

When pure and crystallised, calamine is colourless and transparent; but it is frequently tinged with yellow, brown, or green, by the intermixture of a minute portion of the carbonate of iron or copper. The crystals are rhomboids, both obtuse and acute (*figs.* 11, 12.), and sometimes triangular dodecahedrons. (*fig.* 20.) They are generally small, or even minute, having a shining vitreous lustre, both externally and internally. It is very little harder than calc-spar, and may be easily scratched with a knife. Specific gravity, 3·6 to 4·4.

The crystallised varieties form but a small part of the calamine which is raised. It is oftener massive, with a more or less perfectly lamellar structure; or earthy and opaque, somewhat resembling, excepting in its less specific gravity, the earthy carbonate of lead. Sometimes, also, it is compact, forming small distinct globular and reniform masses, which are translucent, and break with an uneven or splintery fracture. The earthy kind often occurs in masses which have a cellular or corroded appearance. All the varieties have nearly the same chemical characters, being infusible by the blowpipe without addition; but heated on charcoal, they give a white vapour, which condenses around the specimen so assayed. Soluble in nitric acid, with effervescence; the solution affording a white precipitate on the addition of ammonia.

There is another species of carbonate, containing about 20 per cent. of water, which is earthy and pulverulent; but it has not been ascertained to exist in England. The water becomes apparent by calcination: in other characters it resembles the common calamine.

In England, the greatest depository of calamine is the Mendip Hills, near Cross in Somersetshire; a good deal is obtained from Holywell in Flintshire, where there are also lead mines, and near Castleton in Derbyshire; near Bristol likewise, and in the lead mines of Durham, calamine is raised.

In the lead mines, calamine is found filling or partially filling veins, either alone or intermixed with galena and other ores of lead. Phosphate of lead and calamine are not unfrequently met with in contact: but this mineral forms likewise considerable beds in the secondary rocks of some countries, particularly the carboniferous limestone. It is generally accompanied by the succeeding species.

SILICATE OF ZINC. (*Calamine; Electric Calamine; Siliceous Carbonate of Zinc.*)

There is a great similarity in the general appearance of this mineral and the carbonate of zinc. It occurs crystallised, compact, lamellar, and earthy; white or yellowish-white; transparent when crystallised, opaque when earthy. The crystals are derived from a right rhombic prism; but being generally very small, and aggregated confusedly together, their form is not readily distinguishable. Hence the two species have frequently been confounded together; and, probably, some specimens analysed may have contained both substances, and occasioned opinion that this was a *siliceous carbonate* of zinc. They may, however, be distinguished, when pure, by the greater hardness of the silicate, the circumstance of its not effervescing on the application of acid, and more particularly because it becomes electric by friction. It affords water by calcination, and on exposure to the blowpipe it swells considerably, but does not melt without the addition of a flux. The solution in acids is gelatinous, affording a white precipitate when ammonia is added.

Both species are used indiscriminately for the production of zinc, and are frequently melted with copper, without previous reduction, to form brass.

SULPHATE OF ZINC. (*White Vitriol; Zinc Vitriol.*)

Like the sulphates of iron and copper, this salt is produced by the decomposition of the sulphuret. It is found occasionally, in small quantity, in old mines, and principally in such parts of the workings as have been abandoned.

ANTIMONY.

ALTHOUGH this is far from being a very abundant metal in nature, compared with iron, copper, and lead, it is of considerable importance in various manufactures, particularly for the composition of *type metal,* and for the preparation of certain medicines; and consequently may be sought for, when any indications of it are met with, as a substance well worth the trouble of research.

Its ores are—

- Alloys:
  - Native antimony.
  - Arsenical antimony.
- Sulphurets:
  - Grey antimony ore:
    - Nickeliferous sulphuret.
    - Zinkenite.
    - Jamesonite.
    - Bournonite.
- Oxides:
  - White oxide of antimony.
  - Earthy oxide of antimony.
  - Red antimony ore.

The only one of these species which is at present found in sufficient abundance to be of any importance, is the grey antimony, or simple sulphuret.

NATIVE ANTIMONY

Is a rare mineral, which occurs occasionally with antimonial and arsenical ores, filling small veins, as at Dauphiné and the Hartz. It is perfectly metallic, nearly as white as silver, and cleavable parallel to the faces of the regular octahedron; but it has not been observed crystallised. Specific gravity, 6·7; somewhat sectile and frangible: before the blowpipes it melts and gradually evaporates.

The arsenical antimony somewhat resembles the foregoing mineral, and is equally scarce. It occurs principally in the same or similar localities. It is volatilised by exposure to the blowpipe; and the arsenic is recognisable by its garlicky odour.

GREY ANTIMONY ORE. (*Sulphuret of Antimony.*)

It is of a dark lead-grey colour, with a metallic or semi-metallic lustre, crystallising in right rhombic prisms, of which the angles are 91° 20′ and 88° 40′; but more frequently in forms derived from this solid. (*figs.* 36, 37.) The crystals seldom exhibit two terminations, being usually aggregated in a radiated form: sometimes they are very slender, acicular, or even capillary, intersecting each other in all directions; and the surface, which is generally bright, is sometimes beautifully tarnished, exhibiting the prismatic colours. When massive, the grey antimony ore has either an imperfectly crystalline or compact structure. It is soft and in thin laminæ, very flexible. The specific gravity is from 4·3 to 4·6. Like the two preceeding species, it is entirely volatilised by the blowpipe, and with a moderate heat, giving off abundance of white vapour.

The sulphuret of antimony sometimes entirely fills the veins in which it occurs; but these are not in general of great extent. They traverse, in some countries, granite, gneiss, and mica-schist; but it also accompanies other ores, as a subordinate matter, particularly those of silver and of lead. We have already noticed that in Cornwall it occurs with the white carbonate of lead; and it is found occasionally with crystals of calc-spar, and with zinc and copper ores. In Cornwall it is generally met with in the cross courses, or north and south veins; not in those which principally afford copper and tin, running east and west. In Dumfriesshire there are antimony mines, where the veins traverse transition rocks.

NICKELIFEROUS SULPHURET OF ANTIMONY;

At present a very rare mineral, of a lead-grey colour, crystallising in the cubic system; specific gravity, 6·45; fusible by the blowpipe, disengaging abundant antimonial vapours: the solution in nitric acid, greenish, giving a green precipitate on the addition of potash or soda.

ZINKENITE; JAMESONITE;

Sulphurets of antimony and lead, differing principally in the proportions of the two metals: the former crystallises in six-sided prisms, but has not been observed in Great Britain. The latter was discovered in Cornwall, imperfectly crystallised, and bearing great resemblance to Bournonite. Fusible by the blowpipe, depositing a yellow oxide of lead on the charcoal, and disengaging white antimonial vapour.

BOURNONITE. (*Endellion; Triple Sulphuret.*)

This mineral is a combination of the sulphurets of antimony, lead, and copper. Its crystals, of a dark-grey colour, are generally very small and brilliant, and exhibit several modifications of a rectangular prism. The blowpipe volatilises the antimony, produces the yellow oxide of lead, and finally a globule of metallic copper results.

WHITE OXIDE OF ANTIMONY.

This mineral, which is a pure oxide of antimony, does not appear to crystallise externally, but has, when massive, a crystalline structure. It is sometimes yellowish white, and often has a pearly lustre ; soft and extremely tender. Specific gravity, 5·56. It is fusible even in the flame of a candle, and is quickly volatilised by the blowpipe.

It is not uncommon to find this species with the other ores of antimony, but in very small quantity.

EARTHY WHITE ANTIMONY ORE

Is a hydrous oxide, which occurs in an earthy or pulverulent form, generally coating the surface of the grey sulphuret. The chemical characters are the same as of the preceding species, except that this affords water by being heated.

RED ANTIMONY ORE. (*Kermes.*)

This is a combination of the sulphuret with the oxide of antimony. Its colour is a brownish or dark-purplish red; the surface brilliant, but without metallic lustre. Its usual form is that of acicular crystals, divergent or interlaced, which appear to be very slender rhombic prisms. It is very soft and tender. Specific gravity, 4·6. Being found sometimes on the surface of the grey sulphuret of antimony, it would appear to be the result of a partial decomposition of that mineral. It is met with also occasionally among ores of arsenic, intermixed with earthy minerals. At present it is a very scarce mineral, but would be very profitable if found in sufficient quantity to smelt.

MANGANESE.

THE ores of this mineral are not numerous, nor are they generally found in great abundance, although it is one of the most widely distributed metals in nature; since, like iron, it enters in small proportion into the composition of an immense number of earthy minerals and several metallic ores. The greater part of the hydrates of iron, and the carbonate (including the clay ironstone), contain manganese, either as an oxide or a carbonate: it is met with in slate, marble, and many crystalline minerals, particularly mica (one of the constituents of granite), of which it is generally the colouring-matter.

The only ores of manganese which are employed in manufactures, are the oxides, which are by far the most abundant. They are applied to various purposes, particularly the production of the hydrochloric acid, and in the manufacture of glass, to destroy the greenish colour which it often has; but the metal itself is not obtained from them. This is an operation of some difficulty, and would be useless, as manganese absorbs oxygen immediately and rapidly on exposure to the atmosphere; thus returning to its natural state.

Ores of Manganese.

Sulphuret.		
Oxides:		
Peroxide.	Grey manganese ore.	Pyrolusite.
Hydrous oxide.		Acerdèse.
Deutoxide of manganese.		Braunite.
Barytiferous oxide.		
Carbonate.		
Silicate.		
Phosphate.		

ALABANDINE. (*Sulphuret of Manganese.*)

A mineral of a dark grey colour, with a semi-metallic lustre. It is somewhat brittle; the specific gravity, 3·95. It occurs in imperfect crystals, or small masses, having an interrupted crystalline structure, or coating other substances. After exposing it to the oxidising flame till the sulphur is evaporated, if it be melted with soda, the result will be an imperfect glass, of a green colour, which is soluble in water.

It is at present a rare substance, but has been observed in some of the Cornish mines.

GREY OXIDE OF MANGANESE.

Under this name are included two species, extremely similar in their appearance, but differing considerably in their properties, the peroxide being much more profitable than the hydrous oxide, whether for the production of the hydrochloric acid, or for the quantity of oxygen which they afford when heated. They are both, however, frequently intermixed in nature, and are employed without distinction.

They occur crystallised in long prisms, generally of eight sides, terminated either by two or four planes, which are often aggregated laterally and deformed by their mutual pressure; or they form masses of coarse divergent fibres. Some specimens very much resemble the grey sulphuret of antimony in the form and aggregation of their crystals, but their colour is darker, and, of the two species, the peroxide has a more decidedly metallic lustre than the other. The grey manganese ores have also sometimes a granular structure approaching to compact; such specimens are generally full of small cavities, in which is an earthy variety of the same substance, of a brownish or sooty black colour: it is extremely soft, soiling the fingers strongly when touched, and easily reduced to powder. This kind has been named *wad*, or *black wad;* and occurs sometimes in considerable quantity, forming separate and distinct masses in the deposits of grey manganese ore, which are globular or reniform, or resembling fungi, of various sizes.

The specific gravity of the peroxide (the crystalline and compact varieties) is 4·8 or 4·9; that of the hydrous deutoxide, 4·3: the latter is rather the harder of the two, and will scratch fluor-spar; the peroxide will scratch calc-spar, but not fluor-spar. They may further be distinguished by this circumstance, that the peroxide (pyrolusite), when crushed to powder, is black; the hydrous oxide, brown. It must be observed also, that the crystals of the peroxide are derived from an *oblique*, and the hydrous oxide from a *right* rhombic prism.

Grey manganese ore has for many years been obtained in large quantity at Upton Pyne in Devonshire, where all the varieties above described are found. The mines are situated in greywacke slate, which is intersected by large and small veins, affording, with the manganese, brown hæmatite. The ores of iron and manganese have a great affinity, and are found combined in the most variable proportions. Thus, the brown hæmatite generally contains a portion of oxide or hydrate of manganese; and when the hæmatite is black, or nearly so, it will be found that the quantity of manganese is so great as to produce a violet tint when fused with borax. Umber and wad are both compounds of the hydrous oxides of iron and manganese: in the former the iron preponderates; in the latter, the manganese.

The grey manganese ores are not confined to Devonshire. In Cornwall they are found in clay-slate, at Kingston Down, near Callington; and in the neighbourhood of Trebartha: they are also raised in Warwickshire, and the county of Aberdeen, in the mountain limestone.

BRAUNITE. (*Deutoxide of Manganese.*)

This species is very different in appearance from the foregoing ones. Its crystals, which are generally very small, are square octahedrons, the summits being occasionally replaced by four additional faces. Lustre metallic; powder brown; specific gravity, 4·81; scratches felspar, but is scratched by quartz. Hitherto it has not been observed in England, and is still a rare mineral in the few localities where it is found. If met with in sufficient quantity, it would be advantageous for the production of chlorine.

BARYTIFEROUS MANGANESE ORE,

The peroxide of manganese combined with the earthe baryta. It has a blueish-grey colour, passing to steel-grey, with a more or less metallic lustre. It does not crystallise, but forms masses of various sizes, which are sometimes granular, sometimes appearing to consist of twisted fibers closely interlaced. Specific gravity, 4·4. It is found in some of the deposits of the peroxide, as at Perigord, where it is made use of together with the other species.

All these minerals are infusible by the blowpipe without addition: when melted with borax, or the glass of borax, they produce an amethyst-coloured glass. The same tint, which may sometimes be observed in window glass, is caused by the manganese having been used in too large a proportion, for the purpose of destroying the greenish colour which otherwise generally exists in it.

CARBONATE OF MANGANESE. (*Diallogite.*)

Like the carbonate of iron, this mineral has for its primary form an obtuse rhomboid. It offers occasionally other figures, deviable from this one, but its crystals are scarce: it is more usually massive and lamellar; generally of a pale rose colour, but sometimes yellowish white, or brown. Specific gravity, 3·2 to 3·59. It effervesces feebly with nitric acid; and when melted with carbonate of soda, it produces a frit, or imperfect glass, of a green colour.

It is far from being an abundant mineral, being found at present in small veins in some few localities on the Continent, particularly the Hartz Forest, Kapnic in Hungary, and Transylvania.

SILICATE OF MANGANESE.

This mineral, of which there are several varieties, varying in the proportions of silica and manganese, can scarcely with propriety be called an ore of manganese. The colour of some specimens is a beautiful rose red, others are yellowish, or grey. They are sometimes made use of for snuff-boxes and other ornamental purposes, being very hard, and not brittle.

ARSENIC.

THE ores of arsenic are neither numerous nor abundant, but some of them are pretty widely distributed, accompanying other metalliferous minerals, particularly the red silver ores and the arseniurets of cobalt and nickel. They are —

- Native arsenic.
- Sulphurets:
    - Red orpiment.
    - Yellow orpiment.
- Oxide of Arsenic.

NATIVE ARSENIC.

When freshly broken arsenic is of a pale lead-grey colour, or nearly white, with a perfectly metallic lustre; but it tarnishes rapidly by exposure to the air, and becomes black. It does not crystallise, but forms masses of various sizes, which have externally a mammillated form, and are often composed of parallel concentric layers. The specific gravity, when pure, is 8·3; but it varies considerably, and is sometimes below 6. Fusible and volatile by the blowpipe, in a closed tube, or on charcoal.

It is not found in sufficient quantity to be collected on its own account, and is generally thrown aside, being injurious in the smelting of all other ores. It has not yet been met with in England.

RED ORPIMENT. (*Realgar.*)

This mineral is of a brilliant crimson colour, approaching to scarlet, and semi-transparent. Its crystals, which are sometimes very complex, are derived from an oblique rhombic prism. They are not always very brilliant externally; but, when broken, the lustre is perfectly vitreous. It is very soft and fragile; the specific gravity, 3·6; and it is so volatile that, when heated in a closed tube, it deposits crystals on the interior of the upper part. These characters will distinguish it from the red silver ores, for some of which it might possibly be mistaken, especially when the crystallisation is indistinct.

YELLOW ORPIMENT.

A sulphuret of arsenic, containing a larger proportion of sulphur than the preceding. Its colour is a bright golden or lemon yellow, without any metallic brilliancy; but it has a degree of pearly lustre, which, together with its tendency to split readily into thin laminæ, gives it considerable resemblance to talc. Its chemical characters are the same as those of realgar.

These two substances are employed in painting, although the red orpiment is not a permanent colour. Like native arsenic, they occur in veins which afford the red silver ores, and the ores of lead and cobalt, but have not hitherto been met with in Great Britain.

OXIDE OF ARSENIC.

A mineral which occurs but rarely, of a white colour, and pulverulent. It may be distinguished from all other metallic minerals which resemble it in colour and texture, by the strong odour of garlic which is immediately perceptible when it is heated.

COBALT.

THERE are but few ores of this metal, and two only are at present sufficiently abundant to be explored for commercial purposes. They furnish the colouring-matter of smalt, and the blue colour which is made use of in potteries, glass-staining, &c. They are found principally in the oldest and crystalline rocks, such as gneiss.

It does not occur as a native metal, but we are acquainted with the following combinations: —

Sulphuret of cobalt.
Arsenio-sulphuret.
Arsenical cobalt.
Sulphate.
Arseniate.

SULPHURET OF COBALT.

A metallic mineral of a pale steel-grey colour, inclining to yellow: when broken it appears to have a fine granular structure. It has been found in irregular masses, and sometimes, but rarely, crystallised in regular octahedrons, near Riddarhytten, in Sweden.

COBALT GLANCE. (*Silver-white Cobalt; Bright-white Cobalt; Cobaltine; Grey Cobalt, in part.*)

This ore of cobalt is quite white, with a perfectly metallic lustre, and considerable brilliancy. It is generally crystallised, assuming the forms of the cubic system, and particularly, like iron pyrites, the pentagonal dodecahedron, the icosahedron, and the cube and octahedron modified by planes which tend to produce these solids. Its colour and greater specific gravity (6·29), however, sufficiently distinguish it from pyrites: it is also more brittle.

When exposed to the action of the blowpipe, after being heated in the oxidating flame, it melts, the heat disengaging arsenical fumes: the globule, remelted with borax, communicates to it an intense blue colour. The latter character belongs to *all* the ores of cobalt; but, on heating the preceding mineral (sulphuret of cobalt), no arsenical odour is perceptible.

The largest known depositaries of this ore are in Norway and Sweden, where it is associated with copper pyrites in a stratum of gneiss. A considerable quantity is raised in both these countries, and it has been found, but hitherto very sparingly, in some of the Cornish mines, as in the copper veins of Dolcoath; in the cross veins of Herland mine, which afford native silver; and, with bismuth, at Huel Sparnon, near Redruth: but it has been considered a different species, in consequence of occurring uncrystallised in these localities.

SMALTINE. (*Tin-white Cobalt; Arsenical Cobalt.*)

The colour of this species is not so purely white as of the preceding ore; and by exposure to the air it acquires a slightly reddish tarnish. Its crystallisations belong to the cubic system; but they are similar to those of galena, and do not include the forms of iron pyrites. There is another peculiarity in the crystals of this mineral, namely, that their surfaces are generally convex, and intersected by irregular cracks: it occurs also in small irregular masses, arborescent, and reticulated. The lustre is perfectly metallic, and it is hard and brittle. The chemical characters are the same as of cobalt glance: both species are partially soluble in nitric acid, and their solutions are rose-coloured, approaching to violet: if alkali be added, the smaltine will give a violet-blue precipitate; the cobalt glance, one of a reddish-brown colour. It must be remembered that the tin-white cobalt (smaltine) is an arseniuret of cobalt, and contains no sulphur; whereas cobalt glance is a combination of cobalt with both arsenic and sulphur.

OXIDE OF COBALT. (*Earthy Cobalt; Peroxide of Cobalt.*)

This substance, which is seldom met with in a state of purity, is black and pulverulent, forming small masses in the deposits of cobalt glance and smaltine, or coating these and other ores in the vicinity. It is oftener intermixed with a large proportion of earthy matter, to which it imparts a dark brown or blackish colour.

In England it has been found in sandstone, at Alderley Edge, Cheshire, with copper pyrites: the same stratum is coloured by it in various parts farther south, and it occurs in some of the Cornish mines.

Its identity may easily be ascertained by fusion with borax, as the smallest particle of it will produce an intensely blue glass; while the black oxide of copper, which resembles it in appearance, communicates to the flux a crude green colour.

We mention this mineral (like some others) because it may be the indication of a deposit of cobalt glance, or arsenical cobalt, in the vicinity.

SULPHATE OF COBALT. (*Red Vitriol; Cobalt Vitriol.*)

Like the preceding mineral, this may be met with, and lead to the discovery of more profitable ores. It is soluble, and exists in the water of some mines: when solid it forms small stalactites, or slender divergent crystals, of a dull red colour. When calcined, it gives off water, and becomes of a light rose-colour.

ARSENIATE OF COBALT. (*Cobalt Bloom.*)

A mineral of a pale rose-colour, which is found in very small semi-globular masses, consisting of delicate fibres, or acicular crystals, generally on the surface of other ores of cobalt. In Cornwall, it has been found with arsenical cobalt and copper ores; in Stirlingshire, in the silver mine at Alva. The arsenical fumes it emits when heated, and the blue colour it communicates to any kind of glass, readily distinguish it.

BISMUTH.

THIS metal is not found abundantly, nor is it extensively used in arts or manufactures. It is found native, and mineralised by sulphur, and more rarely, as an oxide and combined with arsenic. Its ores are found in the primary strata.

NATIVE BISMUTH.

Of a reddish white colour, perfectly metallic, and breaking with a bright lamellar fracture, the cleavages parallel to the faces of the regular octahedron. When not massive, it sometimes offers a leafy or feathery appearance. Specific gravity, 4·36. It is extremely fusible, and when melted over charcoal, deposits on it a yellow oxide.

SULPHURET OF BISMUTH.

This also has a perfectly metallic lustre, but the colour is pale steel-grey, or yellowish grey. It occurs in the form of small prismatic and acicular crystals, or small fibrous masses composed of these needles, and often much entangled in the earthy minerals and other ores which accompany it. It is seldom quite pure, containing generally a small proportion of lead or copper, or both.

OXIDE OF BISMUTH

Is a white opaque mineral, without metallic lustre; sometimes it is shining and lamellar, sometimes dull and earthy. Like the native bismuth, it may be recognised by the yellow colour which it deposits on charcoal, before it is reduced to the metallic state.

MERCURY.

THE ores of this metal have not yet been observed in Great Britain or Ireland. We shall, however, describe them, as it is possible they may exist in these countries, or the reader may explore other tracts, where there is a stronger probability of meeting with them. Its ores are—

- Alloys:
  - Native mercury.
  - Amalgam.
- Sulphuret.
- Chloruret.

NATIVE MERCURY.

This metal is too well known, and too peculiar in its appearance, to require description. It does not occur abundantly in the liquid state, but appears in the form of globules, of different sizes, on the exterior of masses of cinnabar, and sometimes fills cavities in the same ore. It is not always pure, containing sometimes a small quantity of silver.

when the proportion of this metal amounts to about one third of the weight of the mass, it becomes

NATIVE AMALGAM. (*Argentiferous Mercury.*)

Its colour is perfectly silver-white, metallic, but with little lustre. It is very soft, and may readily be cut with a knife. It is generally crystallised, assuming the form of the rhomboidal dodecahedron, which is often modified by numerous small planes. It may be easily distinguished from native silver, by means of the blowpipe. As the mercury is volatilised, the crystalline form disappears, and after a short time, a small bead of silver remains.

CINNABAR. (*Sulphuret of Mercury; Vermillion.*)

This mineral is of various shades of crimsom red: the light-coloured varieties are slightly transparent, with a vitreous lustre, and granular structure; while the darker specimens incline to steel grey, with a semi-metallic appearance. When scratched, the streak is bright scarlet. It occurs in considerable masses, furnishing, together with the native mercury, all the quicksilver used in the arts and manufactures: sometimes, but more rarely, it is crystallised, in forms derived from an acute rhomboid (*fig.* 20.). Its specific gravity is 8·09, considerably higher than that of the red silver ores; and it is completely volatilisable by heat, the whole gradually disappearing, with a sulphureous odour. Cinnabar is sometimes rendered impure by an intermixture of carbonaceous matter; and it then has a darker grey colour, with a tinge of crimson, and scarcely any lustre. This intermixture arises from its occurring in the sandstone and shale of the coal formation, in which, in some countries, it exists in large quantity. It is found also in the limestone of the same system; and, less frequently, in clay-slate, as in Hungary. The great quicksilver mines of Idria in Carniola, and Almaden in Spain, are situated in the coal formation.

PLATINA.

THIS metal, which is intermediate in colour between steel and silver, occurs only in the metallic state, seldom pure, but alloyed with a small quantity of iridium, rhodium, palladium, osmium, and sometimes gold. It is found in small irregular grains, from the size of sand to that of a pea, very rarely in large, masses. Its weight is greater than that of any other metal: in the native state, its specific gravity is about 17. It is insoluble except in nitro-hydrochloric acid, and infusible by the blowpipe. It is found generally in the deposits of gold-sand, intermixed with grains of zircon, spinel ruby, magnetic iron, &c. It has been observed also in some auriferous veins in South America, but still in a granular form; and, within a few years, it has been obtained from the western side of the Oural Mountains, accompanied by gold.

MINERAL ROCKS AND EARTHS.

HAVING described all the ores which are at present made use of, either for reducing them to a metallic state, or for other purposes, and many other metalliferous minerals of which it may be useful to have some knowledge, we shall give some account of a few earthy substances, which are met with abundantly or frequently in the same localities, either as veinstones or as constituents of the rocks and strata to which we have adverted in the former part of this work.

QUARTZ. (*Rock Crystal; Amethyst; Fat Quartz.*)

Under the name of rock crystal, this substance, in its purest state, is familiar to most persons; but the massive quartz which partially fills the metallic veins of Cornwall and other mining districts has in general but little transparency. It is mostly white, with a fatty lustre, which has obtained for it the denomination of *fat quartz;* or tinged with green and brown, by the oxide of iron or the copper ores intermixed with it.

Crystals of quartz, however, or rock crystals, are by no means uncommon in the cavities of these veins; their most usual form is an hexagonal prism, terminated by an hexagonal pyramid (*fig.* 15.); less frequently both ends are pyramidal. In granite, quartz generally appears in the form of grains, which are more or less transparent, colourless or greyish. In the cavities of granite, fine groups of crystals are sometimes met with, as the brown rock crystals of Cairn Gorm in Scotland. Amethyst is quartz, coloured by a small portion of the peroxide of manganese. But in all these varieties, quartz preserves the same degree of hardness, which is considerably greater than that of glass, and, when broken, presents always a conchoidal fracture and vitreous lustre. Sand and sandstone are but modifications of the same substance (the earth silica), generally much coloured by the hydrate and oxide of iron. Flint also is quartz, with a different texture.

The specific gravity of all these varieties is about 2·6: they are unalterable by acids, and infusible by the blowpipe alone; but when melted with potash or soda, they form glass. It may be remarked also, that if two pieces of quartz, of any kind whatever, be rubbed together, they emit a peculiar and somewhat disagreeable smell, and in the dark a faint phosphorescent light is perceptible.

FELSPAR. (*Adularia.*)

A crystalline mineral of a greyish white or flesh-red colour; sometimes also white and yellowish white; generally opaque or slightly translucent; but in some kinds of porphyry the crystals of felspar are perfectly transparent and colourless.

Its crystals, which are sometimes very complex, are derived from an oblique rhombic prism; and whether crystallised or massive, except in the compact variety, felspar presents a crystalline or lamellar structure, in which two cleavages* are very distinct. When it is compact, the fracture is either fine granular or conchoidal, without any lustre. In this state it forms the base of most porphyries.

The hardness of felspar is much less than that of quartz, but yet considerably greater than that of glass: the blowpipe fuses it into a white enamel, insoluble in all acids; specific gravity, 2·4 to 2·58.

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* One parallel to the bases of the primary crystal; the other, perpendicular to it, is parallel to a plane passing through the lesser diagonal of the bases.

CALCSPAR.

This is one of the many varieties of carbonate of lime; a species which includes all kinds of limestone, calcareous marble* chalk, and some other minerals, which it is not within our province to describe. Calcspar is generally transparent, or nearly so, and either colourless or yellowish: sometimes, however, it has a red or brown colour communicated to it by the oxides of iron and manganese. The massive calcspar which occurs as a veinstone with metalliferous minerals, is generally white or brownish, and nearly opaque; affording with great ease three bright cleavages, which indicate an obtuse rhomboid as its primary form. (*fig.* 11.) It exhibits, perhaps, more variety of crystallisation than any other mineral. (*figs.* 12, 13. 18, 19, 20, 21, 22, 23.) The scalene dodecahedron, both more obtuse and more acute than *fig.* 20., occurs in combination with the six-sided prism and the planes of various rhombs of different degrees of obtuseness.

Marble is the same substance wherein the crystalline structure is interrupted, and it is granular; but still showing the bright cleavage surfaces in each grain: limestone is still more compact.

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* Or *true* marbles; because some kinds of serpentine, which is a *magnesian* mineral, have been erroneously called marble.

All the different kinds of carbonate of lime effervesce briskly when acids are applied to them; and when subjected to a sufficient heat, they become caustic lime.

FLUORSPAR. (*Fluor; Fluate of Lime.*)

This mineral, though much less abundant than the last, is very widely distributed in nature, and fills the greater part of the metalliferous veins in several localities. Its colours are various, and generally bright: in Durham and Yorkshire, it is most frequently violet, with a tint of pale green in the crystals, which are transparent; in Derbyshire, the most common colours are violet and dark indigo blue, and fine specimens have been obtained of a bright yellow colour: sometimes it is limpid, and more rarely pale rose-colour. It is generally transparent, unless where the colour is very dark; and frequently enclosing crystals and small particles of copper pyrites, a mineral with which it is almost constantly associated. In some parts of Cornwall, bright green fluor is the veinstone of several copper-mines.

Its crystals are generally cubic, or the edges of the cube are replaced by two planes; and very often each face is surmounted by a very flat pyramid (*fig.* 8*): the primary form is the regular octahedron, which however seldom occurs; but the cleavages are generally evident on the surface of the crystals, and are easily obtained. In Derbyshire, fluor occurs with a coarse fibrous structure, of various shades of blue and purple, very much resembling amethyst: it forms nodules, of different sizes and and forms, in the veins of sulphate of baryte which traverse the mountain limestone.

Fluor is harder than calcspar, but may readily be scratched by glass or steel. Most varieties become phosphorescent when heated.

Copper pyrites, Galena, Blende, and Calamine are the ores most usually met with in the localities of fluor.

GYPSUM. (*Selenite; Plaster-stone; Alabaster; Sulphate of Lime.*)

Alabaster, a granular variety of this mineral, is well known as the material of which vases, small statues, and other ornamental objects, are formed. The crystallised varieties are called selenite. The crystals are generally colourless and transparent, with a strong tendency to split in one direction only, and a somewhat pearly lustre; very rarely it is compact. All the varieties are extremely soft, in most cases yielding to the pressure of the nail. The granular kind is massive, and is generally associated with beds of rock-salt, both in Cheshire and various parts of the Continent; the two substances forming considerable deposits in strata of clay. In Cheshire and Somerset it is generally of a flesh-red colour; and in other localities it is often grey or bluish. When calcined, it becomes plaster of Paris, and may be recognised by its solidifying when mixed with water.

CARBONATE OF BARYTE. (*Witherite.*)

The carbonate and sulphate of baryte are the heaviest of the earthy minerals, a circumstance which has caused them to be mistaken for the ores of metals.

Carbonate of baryte is rarely crystallised; but is massive, filling veins of considerable width, and, when broken, very much resembling alum in its appearance. It is found also in large globular or spheroidal masses, having a coarsely radiated structure.

In hardness, it is intermediate between calcspar and fluor; the specific gravity, 4·3. It effervesces with acids, but much more feebly than carbonate of lime; and when powdered and thrown on hot coals, it is slightly phosporescent. By calcination it becomes caustic, and soluble in acids.

Galena more frequently accompanies the carbonate of baryte than any other ore; and as a veinstone it is more abundant in England than any other country.

HEAVY-SPAR. (*Sulphate of Baryte.*)

Unlike the carbonate of baryte, this mineral is almost constantly crystallised, or crystalline in its structure. It is very brittle, a slight blow affording brilliant cleavages, parallel to its primary form, a right rhombic prism. The crystals are often tabular, and exhibit but little of the primary faces. (*figs.* 32. 35. 39.) They are generally transparent, colourless, or tinged with brown, seldomer with red or dark grey. It is about as hard as carbonate of baryte, and rather heavier.

Sometimes it occurs in small columnar masses, or bundles of fibers, strongly resembling the carbonate of lead; sometimes a divergent radiated structure. This kind is often brown, with a resinous lustre. It is also met with granular, resembling marble; and occasionally, as in Derbyshire, earthy and opaque.

Heavy-spar does not effervesce with acids; is partially soluble in nitric acid; and is fusible, with some difficulty, into a white enamel. The ores most usually accompanied by heavy-spar are those of lead, silver, and mercury.

CHLORITE.

A mineral of a dark green and sometimes blackish green colour, generally having an earthy texture, more or less indurated, or appearing to consist of minute scales: these scales are crystalline plates, resembling talc, but they are rarely of such a size as to allow their form to be distinguished. When perfect, they appear to be hexagonal plates. It is extremely soft and tender.

Chlorite is one of the minerals which often accompanies metallic ores in the primary strata. In Cornwall it occurs in most of the tin and copper veins, but rarely in those which contain lead ore.

PHYSICAL CHARACTERS

OF

MINERALS.

ALTHOUGH it is not intended to give the reader an elaborate treatise on the physical characters of minerals, yet, as in the description of ores and other substances, these characters or qualities are necessarily adverted to, as descriptive of the different species, it is well that any one, whose occupation may lead him to investigate the riches of the mineral kingdom, should have some acquaintance with them, and also with the terms by which they are sometimes, it may be said, *technically* described, both in this and other works on mineralogy. It has been thought more advisable to devote a few pages to the explanation of such terms, than to repeated lengthened descriptions in the body of the work, in order to avoid the use of them.

In all minerals several of these characters are observable; such as form, colour, weight, transparency, or opacity, &c. They are all included in the following table, where, for the sake of greater facility in referring to them, they are placed in alphabetical order:—

- Adhesiveness to the tongue.
- Colour.
- Double Refraction.
- Electricity.
- Flexibility.
- Elasticity.
- Form:
  - Regular or crystalline,
  - Irregular.
- Fracture.
- Frangibility.
- Tenacity.
- Hardness.
- Lustre.
- Magnetism.
- Odour.
- Phosphorescence.
- Specific Gravity.
- Structure.
- Taste.
- Touch.
- Transparency.

ADHESIVENESS TO THE TONGUE.

A character belonging to but few minerals, and which arises from their disposition to imbibe moisture rapidly. They are mostly in a state of decomposition.

COLOUR.

The colours of minerals are often characteristic of them; but they also frequently arise from an intermixture of some other substance, which is not essential to their composition. In the latter case, the same species often occurs of very different colours, as quartz, which when perfectly pure is colourless, but is sometimes purple, (amethyst); sometimes yellow, (Brazilian topaz); or brown, (Cairngorm stone), &c. On the other hand, cinnabar is always of a bright crimson colour, unless rendered dark and dull by some impurity: in carbonate of copper, one species is deep blue, the other of a brilliant green colour. Some ores, which are of an iron or lead-grey colour, exhibit occasionally on their surface brilliant prismatic colours, which may be considered accidental, and may be easily removed.

DOUBLE REFRACTION.

The transparent variety of calc-spar, commonly called Iceland spar, is well known to many persons, as possessing in a strong degree the property of double refraction. A fragment placed on a written or printed word, will give the appearance of its being written or printed twice over, the distance between the two images depending on the thickness of the fragment through which it is viewed. For a long time it was supposed to be a property peculiar to this substance, which obtained the name of *double-refracting spar;* but optical researches, particularly those regarding the polarisation of light, have proved that it belongs to all crystallised transparent minerals, except those which assume the forms belonging to the cubic series. (See *Crystalline Form.*) In the greater number, however, it is not immediately perceptible, being very feeble, compared with that of carbonate of lime.

ELECTRICITY.

The power of exciting electricity by friction has been known for ages to exist in amber.* There are many other minerals which have the same property, but in some few it may be excited by simply warming them over the flame of a candle; as, for example, electric calamine.

FLEXIBILITY.

Most of the native metals, and some few other substances, are so flexible as to bend by gentle pressure in various directions, but they are not generally elastic. There are some minerals, however, which are not only flexible, but elastic, as *mica;* and this property will generally distinguish it from talc, which is only flexible.

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* *Electrum* of the ancients; whence the name electricity.

FORM.

When minerals occur in a definite form, whether crystallised or otherwise, it is desirable to notice it. In some cases they cannot be said to possess *any* positive external form; as when they entirely fill a vein, and are *massive*, the mass being bounded only by the walls or sides of the vein. But the same substance often appears, under other circumstances, either crystallised or in detached masses, having a form which is peculiar to them. Thus, radiated iron pyrites and hæmatite are generally found in nodules which are somewhat *globular*, or *reniform* (kidney-shaped). Other minerals have a resemblance to part of a bunch of grapes closely pressed together, and are termed *botryoidal*, as the radiated sulphate of barytes, phillipsite, &c.: when the spherical portions of the surface are larger, the form is termed mammilated.

Arborescent, dendritic, ramose, are applied to the branched and leafy forms and moss-like aggregations of crystals, so constantly met with in some of the native metals, particularly copper and silver.

CRYSTALLISATION, or regular external form, is one of the most important characters of minerals, inasmuch as it is unvarying in each species.

On looking at a collection of crystallised minerals, we perceive a number of symmetrical solids; such as cubes, octahedrons, and prisms, both right and oblique, and a number of other figures, in which we trace the planes of these as the fundamental forms, but which exhibit also a number of additional planes on their angles or edges; for example, in *fig.* 8., where the general form of a cube is apparent; but, instead of the original edges, we perceive narrow planes which replace them: again, in *fig.* 18., we see an hexagonal prism, but not a perfect one; three edges of the upper and three alternate edges of the lower base being replaced by oblique planes. *Fig.* 20., a crystal of common occurrence, may not, on a first inspection, appear to have any relation to either of these two solids; and *figs.* 4. and 5. certainly do not exhibit any resemblance to a cube; yet the two latter, as well as *figs*, 2, 3. 6, 7, 8, 8*, 9, and 10., form part of the cubic series.

It would require the reader to enter too much into the details of crystallography, to explain the transition of all these solids one into another: it will be sufficient to observe, that the triangular planes of *fig.* 6. if extended so as to efface those of the cube, would produce the regular octahedron (*fig.* 2.); that the faces which replace the edges of the cube (*fig.* 8.*), and of the octahedron (*fig.* 10.), are completed in *fig.* 9., and in both cases produce a solid of 12 sides, called the rhomboidal dodecahedron; and that the planes of *fig.* 5. (the icosahedron) are those of *fig.* 4. and *fig.* 2.

In like manner *figs.* 18. and 20. are referable to the series belonging to the rhomboid.

The modern system of crystallography, founded partly on the phenomena of double refraction, has greatly simplified the relations of the almost endless variety of natural crystals, by establishing six simple solids as the *types* or bases of so many different systems of symmetrical forms. These are,—

1. The cube (*figs.* 1. to 10.), *ex.*, native gold, silver, copper; sulphuret of lead; fluor-spar; rock-salt, &c.

2. The rhomboid (*figs.* 11. to 23.), *ex.*, red sulphuret of silver; cinnabar; carbonate of iron, of magnesia, of lime, &c.

3. The right square prism (*figs.* 24. to 29.), *ex.*, oxide of tin.

4. Right rectangular prism (*figs.* 30. to 39.), *ex.*,

carbonate of lead; sulphuret of antimony; heavy-spar.

Note.—This series includes all right prisms which have a rhombic base.

5. Oblique rhombic prism (*figs.* 40. and 41.), *ex.*, blue carbonate of copper.

6. Doubly oblique rhombic prism; an oblique prism, of which the base is an oblique-angled parallellogram; the lateral planes inclining unequally on the base.

It will be seen that the rhomboidal series includes all right prisms of which the base is the regular hexagon, or a figure of 12, 18, or 24 sides; and all the triangular dodecahedrons: some of these are regular (*fig.* 15.*), others are formed by twelve scalene triangles. (*fig.* 20.)

In the square-prism series we find a variety of octahedrons, acute and obtuse; and prisms of 4, 8, and 12 sides, with or without pyramidal terminations.

In the next series there is less symmetry; for the lateral faces of the square prism being all equal, and similarly situated, they are all similarly affected by any modification; but in rectangular and rhombic prisms, only the edges or angles diametrically opposite can be modified in the same manner.

Although the solids of every series may be derived from, or traced to, its fundamental figure, yet this is not the primary form of all substances which crystallise in the solids of that series. Thus, fluor-spar is most frequently met with in cubic crystals, or cubes slightly modified: octahedral crystals of the same substance are comparatively rare; yet the octahedron is termed its primary form, because its structure exhibits a natural tendency to divide into such solids, and it is impossible to obtain from it a cube by mechanical division. This tendency to divide in certain directions only, affording regular solids with fixed angles, is called *cleavage.*

It must here be observed, that crystals, both large and small, often appear irregular, from the circumtance of some of their planes being larger, and some smaller, than others, which in a state of perfect regularity would be equal: but it will be found that their inclinations to each other are still the same.

FRACTURE.

The manner in which minerals break, deserves attention, as the form of the broken surface varies with their texture or structure. In many crystallised substances the structure is manifested in the disposition to break in parallel planes or cleavages; in others, as rock-crystal, the fracture resembles that of glass, presenting curved and somewhat spherical surfaces, meeting at various angles: this is called a *conchoidal* fracture: common flint, and most substances which have a very compact texture, break with a fracture of this kind. In pyrites we have an *uneven* fracture, that is to say, an uneven surface, which is neither conchoidal nor crystalline. In other minerals the fracture, in consequence of the structure, is fibrous or radiated. The kind of lustre in the fracture likewise varies, and should be observed.

FRANGIBILITY.

The ease with which a mineral may be broken, as contrasted with its tenacity or toughness. This property has little relation to their hardness, many hard minerals being very brittle, and some very soft ones difficult to break. The hardness of quartz and of flint are about equal: and analysis discovers scarcely 1 per cent. of foreign matter in the latter substance; yet it is much more tenacious than quartz.

HARDNESS.

This property is ascertained by the ease or difficulty with which a mineral will scratch, or may be scratched by another. The greater number of minerals are much less hard than quartz. This substance, with felspar, fluor-spar, and carbonate of lime, are useful standard points, forming a sort of scale with which to compare others.

LUSTRE.

Not only the *degree,* but the *kind,* of lustre of minerals should be observed, both externally and internally. Some are extremely brilliant, as the carbonate of lead; others moderately so, or bright; some glimmering, and others quite dull. In the varieties of lustre, we observe the adamantine, the vitreous, the resinous, metallic, semi-metallic, pearly, and silky: the latter is confined chiefly to such as have a fibrous structure.

MAGNETISM.

It is scarcely necessary to advert to this property in the oxidulous iron; but it is not so generally known that the metals cobalt and nickel are slightly attractable by the magnet.

ODOUR.

There are few minerals which are distinguishable *by their* odour. In the natural bitumen, and such as contain this matter, it is very evident. Arsenic, and in some cases sulphur, are perceptible when the substances which contain them are thrown on hot coals, or exposed to the blowpipe.

PHOSPHORESCENCE.

This property is confined to a small number of minerals: it is perceptible when they are heated, as in most varieties of fluor and some kinds of heavy spar, and of carbonate of lime.

SPECIFIC GRAVITY.

It is not possible to ascertain exactly the specific gravity or weight of a mineral, as compared with that of water, without the operations of weighing and calculating; but in masses of a tolerable size, habit will enable us to judge in some degree from this character, when it is considered in addition to others.

STRUCTURE.

We have already adverted to the structure of minerals, in speaking of their crystallisation and fracture: we may add, that a peculiar *glisten* may be remarked in some minerals, in consequence of their tendency to cleave in one direction more readily than in others; and that what is called a *foliated* structure is apparent in mica, talc, and yellow orpiment, where only one cleavage is attainable.

TASTE.

Such minerals as are soluble (common salt and the metallic sulphates) are recognisable by their taste, but they are very few.

TOUCH.

Some minerals are distinctly *colder* to the touch than others: topaz, for example, is colder than quartz; the latter, again, is colder than glass. Some appear soapy or unctuous to the touch; they generally contain magnesia: others feel harsh and gritty.

TRANSPARENCY.

When a mineral is not perfectly transparent, it is perhaps semi-transparent; or if in a less degree still, translucent, or translucent only on the edges. The want of transparency arises in many cases from the intermixture of colouring matter which is not chemically combined, as in agates, where the red and yellow colour arise from oxide and hydrate of iron.

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